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AVERAGE DAILY AIR MASS

By ROBT. E. KENNEDY

[U. S. Bureau of Reclamation, Denver, Colo., October 1940]

Studies involving the computation of solar heat available throughout the day require the use of the average daily air mass, or average length of the path in the atmosphere through which the sun's rays must pass as the sun travels across the sky. The air mass ranges from unity at the zenith to about 27 times the zenith value at sunrise or sunset.

Figure 1 provides a means of ascertaining the average air mass at any place on the earth for any day of the year. This figure is the north half of the chart; it is applicable to the Southern Hemisphere by changing signs. It is believed to be accurate within 2 percent for air masses up to 4.0; from there the accuracy shades off to about 5 percent in those parts of the polar region where the change with respect to latitude is rapid as the air mass value approaches 27.0. This limiting line marks accurately the edge of the polar night.

The computation of the chart involves the use of the well-known formula for parallactic angle

$$\text{Cos } Z=\sin \phi \sin \delta+\cos \phi \cos \delta \cos t \tag{1}$$

in which Z=zenith angle of sun, ϕ=latitude, δ=declination and t=hour angle. The declination of the sun changes so slowly from day to day that it may be assumed constant for any one day without appreciable error. Then equation (1) reads Cos $Z=a+b \cos t$ in which a and b are constants. When the zenith angle is 60 degrees or less, an adequate approximation to the air mass is sec Z; values for 60° to 89° have been published in the *Smithsonian Meteorological Tables*, table 100, page 226, fifth edition, 1931. In the latter range, refraction enters in an increasing amount.

One method of computing the average daily value is to assume the air mass thickness to be equal to the secant of the zenith distance at all times. Then $\int \frac{dt}{a+b \cos t}$ provides a means of computing the area under the secant curve. Dividing the area by its base width, the total hour angle, t, from noon to sunset for the particular latitude and declination, gives an average secant height for the curve which is approximately the average daily air mass. This method is correct; but the assumption yields results too large by 12 percent at the Equator, and 16 percent at latitude 60°, for declination 23°27′.

The introduction of refraction, however, produces a curve which is not readily integrable; so resort was made to a graphical method of obtaining the area:

The zenith angle was computed for a number of hour angles, and the corresponding air mass taken from table 100 above referred to. Ten or fifteen points were usually sufficient to adequately define the pattern of the air mass curve, which was of course similar to the secant curve. The area was obtained by adding the ordinates, usually by single degrees except for the first 30° to 50° where the curve was comparatively flat and a 5° unit was used. Dividing the area by the base width gives the average air mass for that particular day and locality. To avoid duplicating this laborious process for every day of the year and every latitude, advantage was taken of the slow daily change of declination. Five or six days a year for 12 latitudes were found sufficient to define the pattern of the curves on figure 1.

These data, as assembled in table 1, were first plotted on two preliminary sets of large-scale curves. On one the air mass was plotted against declination, and on the other it was plotted against latitude. Points taken from these curves were required to fall in smooth lines on figure 1. Only occasional and small adjustments on the preliminary curves were necessary for this requirement, and the uniformity of their pattern was not impaired. This encouraged confidence in the accuracy of the computations.

TABLE 1.—*Average daily air mass*

Latitude	Declination										
	South					North					
	−23°27′	−20°	−15°	−10°	−5°	0	5°	10°	15°	20°	23°27′
90						26.96	10.39	5.60	3.82	2.90	2.50
85					26.96	15.28	10.90	6.34			
80				26.96	14.50	9.76	7.80	7.54	4.96		2.66
75			26.96		9.86	7.40	6.36	5.81	6.14		3.25
70		26.96	14.48			6.25	5.38		4.84		4.62
66°33′	26.96		10.25			5.45			4.39		4.99
63									4.10		4.19
60	12.29		7.17			4.61			3.89		3.86
55									3.57		3.48
50	6.67		5.04			3.83			3.35		3.30
45											
40	4.86		4.08			3.41			3.08		3.02
35											
30											
23°27′	3.59		3.26			2.93			2.80		2.82
20											
15						2.82			2.74		2.80
10											
5											
0	2.93		2.82			2.72			2.82		2.95

In application, this air mass factor is used in Beer's Law. Let I_o equal the solar intensity at the exterior of the atmosphere, and I the intensity at the bottom of the atmosphere, both taken normal to the sun's rays; then $\frac{I}{I_o}$

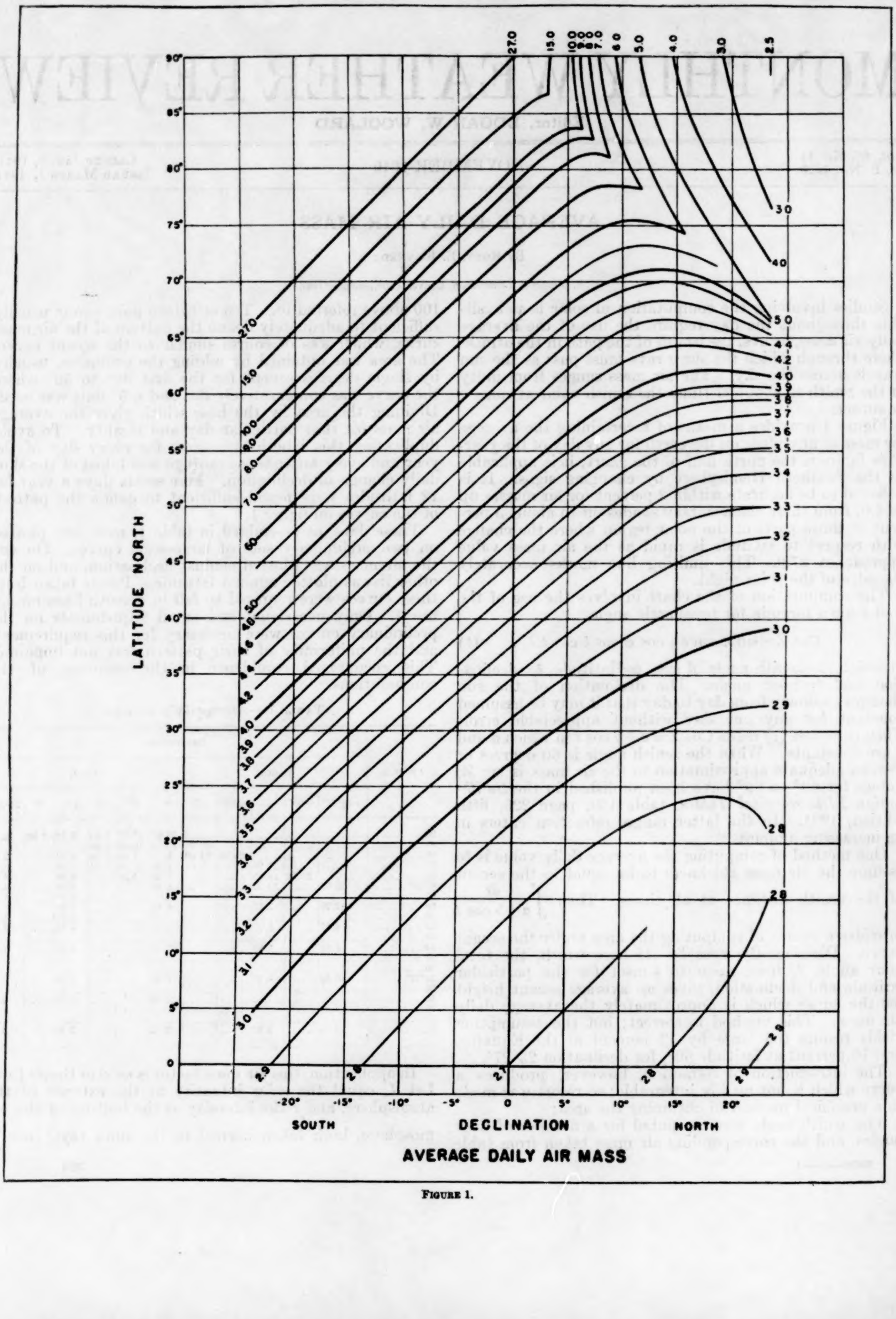
LATITUDE NORTH
DECLINATION
SOUTH
NORTH
AVERAGE DAILY AIR MASS
90°
85°
80°
75°
70°
65°
60°
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
0
-20°
-15°
-10°
-5°
0
5°
10°
15°
20°

FIGURE 1.

is the ratio of atmospheric depletion, and Beer's Law in modified form is

$$\frac{I}{I_o}=a^m, \tag{2}$$

where a is the coefficient of atmosphere transmission, and m, the air mass, is the exponent.

The factor $\frac{I}{I_o}$ has been plotted against air mass, m, by Kimball for several stations in figure 1 of his paper, "Atmospheric transmission coefficients at various altitudes," page 2, MONTHLY WEATHER REVIEW, January 1935. The discussion is continued by Hand in the December 1937 issue; Hand's figure 15, page 427, gives graphically values of a in equation 2 for air masses from 1 to 5.

AEROLOGY IN THE HURRICANE WARNING SERVICE

By GORDON E. DUNN

[Weather Bureau, Jacksonville, Fla., February 1939.]*

The great improvement in the scope and accuracy of the advisories and warnings of tropical storms issued by the United States Weather Bureau has been recognized quite generally, especially by the public on the South Atlantic and Gulf coasts. However, business interests and the general public in this area, encouraged by the constantly increasing efficiency of the Bureau's hurricane warning service, demand still further refinements which, at present, are difficult and often impossible to meet. Most of the senior forecasters will remember when occasionally, because of insufficient land and especially marine observations, hurricanes became "lost" for several days at a time until finally an isolated ship report or a Mexican coastal station would locate the storm many hundreds of miles from the forecaster's projected position. Although the hurricane winds would not often exceed 75 miles in width, in the first two decades of this century hurricane warnings would fly occasionally along many hundred miles of coastline before the storm eventually reached the coast.

The present highly efficient [1] collection of ships' observations in the Gulf of Mexico, Carribbean Sea and South Atlantic [2] Ocean at 7 and 1 a. m. and p. m. E. S. T., and the system of direct calls to ships for special observations during storm conditions should be largely credited to the late E. B. Calvert, formerly Chief of the Forecast Division of the United States Weather Bureau. The ship reporting system now in effect was discussed by Calvert before the 1935 meeting of the American Geophysical Union (1). With the increase in the frequency of observations and the number of vessels included in the system, together with the Coast Guard and Bureau of Lighthouses, the Weather Bureau can accurately locate, most of the time, the position of the storm and its direction and rate of movement.

However, there are other more complex forecasting problems brought about by the notoriously erratic behavior of tropical storms. They may slow to almost a complete standstill for a day or so, may make several turns in their paths, and may even make a complete loop. Some of these erratic movements are apparently pure freaks, such as in the case of the November 1935 storm, but most of them occur at the time a storm leaves the deep easterly current on the southern periphery of the great Azores anticyclone and commences its northward journey through the changeable upper-air currents over and to the east of the southeastern United States. When these latter currents are light, the storm will move very slowly, and when they are changeable the movement of the disturbance likely will be erratic.

Mitchell (2) states, "All tropical storms in the Northern Hemisphere apparently seek to move northward at the first favorable opportunity * * *. Any tropical storm will recurve into a trough of relatively low pressure that may exist when the tropical storm arrives in the same region * * *. No storm will break through and recurve until it reaches a region where south or southwest winds prevail and relatively low pressure to the northward is shown on the weather map."

Mitchell (3) has also discussed the influences of anticyclones on the direction of movement of tropical cyclones, and Bowie (4) has given several examples. Mitchell's conclusions seem, in the main, to be substantiated by the greatly increased observational material of today. Subnormal pressure along and immediately off the Atlantic coast is usually indicative that the normal or at least frequent easterly current aloft in the Florida-Bahamas region has been replaced by a south to west current. However, pressure conditions in front of an advancing hurricane are often flat and indefinite, and often deceptive as regards conditions aloft, consequently a more true and dependable picture of upper air conditions in the entire hurricane region is necessary before any real forecasting of changes in rate and direction of movement of these storms can be attempted.

This article is intended to present the status of aerology in the hurricane warning service at the present time. Upper-air information is obtained from observed cloud types and directions, pilot-balloon ascensions, airplane and radiosonde observations.

Cloud observations are the one source of upper-air information which has shown a deterioration during the past 20 years. At the present time, exclusive of regular Weather Bureau stations within the United States, only two stations, San Juan, Puerto Rico, and Swan Island in the western Caribbean, include cloud data in their regular surface observations. This unfortunate situation has come about through economies which have forced the elimination of precipitation as well as cloud data and through the use of an abbreviated figure code which does not include precipitation, cloud data, or the 3-hourly barometric changes and characteristics. All forecasters engaged in hurricane warning work have considered clouds, especially the cirrus types, important and helpful. The Cuban Jesuit meteorologists, from Viñes to the present time, who have contributed considerably to our knowledge of these storms, have emphasized the importance of clouds in the theoretical and practical treatment of hurricanes. The Rev. Father Eulogio Vazquez, S. J., Belen College, has recently reached further interesting conclusions (as yet unpublished) regarding the relation of upper-air currents to the movement of tropical storms which deserve consideration and trial by other meteorologists. The inclusion of cloud data in all possible land surface reports

*The author, now located at the Weather Bureau office in Chicago, Ill., has revised this paper, with the assistance of Warren O. Johnson of the Jacksonville office, to November 1940.

[1] Since the beginning of the war, there necessarily has been considerable decrease in the number of ship reports, because foreign as well as United States ships had been participating.

[2] The term "South Atlantic" as used in this paper applies to the south portion of the North Atlantic Ocean, or, more specifically, that portion south of latitude 35° N.

should receive the early attention of the United States Weather Bureau. Cloud data contained in cooperative ship reports are considered to be of too doubtful accuracy at present to be utilized.

Meteorology does not yet know the complete answer to the problem of hurricane origin and development. Many students of this subject are attempting to apply air-mass analysis to tropical meteorology, and there has been an increasing number of efforts in the past few years to apply some system of frontal analysis to regions transversed by tropical storms and to the tropical disturbances themselves. Some of these attempts have seemed quite promising. Edna Scofield (5) has recently summarized these viewpoints regarding fronts in the Tropics, and has listed nearly everything published on this subject. Naturally, there are numerous conflicting theories and opinions, with, up to the present time, insufficient free air-data in the Tropics to prove or disprove most of them. Why do some wave disturbances in the Tropics never develop and others reach hurricane intensity? Of course, this question is, as yet, inadequately answered even in extra-tropical regions, and the answer to this and related problems seems locked in the upper air, but airplane or radiosonde observations should provide the meteorological world with the key. Free-air data have been obtained through airplane ascensions by the Navy at Pensacola, Fla., Coco Solo in the Canal Zone, and at St. Thomas in the Virgin Islands. The last two were temporarily discontined in 1940. St. Thomas is by far the best located for most study purposes, as Pensacola is too far north and Coco Solo too near the Equator. The United States Weather Bureau on two occasions maintained an airplane or radiosonde station at Miami, Fla., which is better situated for study than either Coco Solo or Pensacola, but it, unfortunately, has also been discontinued. The Navy, for several years, made airplane ascents at Guantanamo Bay, Cuba, which is very well located, but no longer does so The resumption of airplane or radiosonde observations at Miami and Guantanamo Bay would be valuable for purposes of research and study, and the establishment of several more observational points of like character is most desirable. [The Weather Bureau has now established a radiosonde station at Swan Island in the extreme western Caribbean.] A cursory examination of the St. Thomas airplane observations for only a short period will reveal frequent important changes in the amount of moisture present in the intermediate levels, and that the easterly current in this region is not one homogeneous air mass. In any possible future application in the Tropics of frontal analysis for general use in forecasting, there are indications that upper-air data may be fully as necessary here as in more northerly latitudes.

The Weather Bureau, in cooperation with the Massachusetts Institute of Technology, for the past 3 years has carried on a program providing for the release of sounding balloons during the passage of hurricanes over certain localities. However, the hurricanes have been rather uncooperative and no storm during this period has passed over Cuba where M. I. T. has maintained personnel and no hurricane has passed directly over any station in the United States where the Weather Bureau has maintained the necessary equipment. It is hoped that this project will be continued until soundings are finally obtained within a well-developed hurricane, as it is expected that the data so obtained will add materially to our knowledge of the structure of these storms.

However, it is in the extension of pilot-balloon stations that the greatest progress has been made during the past few years. Beyond the borders of the United States, the main source of this information is through the cooperation of the Pan American Airways. Most of these reports are received through the P. A. A. office in Miami, Fla., and placed on the hurricane teletype there, but some P. A. A. Mexican observations are placed on the teletype at Brownsville, Tex. Twice-daily balloon observations are plotted on Upper-Air Map A from the following regular airport stations of the United States Weather Bureau on the South Atlantic and Gulf coasts: Charleston, S. C.; Jacksonville, Tallahassee, Maimi, Key West, Tampa, Fla; Mobile, Ala.; New Orleans and Lake Charles, La.; and Houston and Brownsville, Tex. The inset maps on Upper-Air Map A do not extend south of Key West, Fla., and Brownsville, Tex.; therefore pilot-balloons runs from stations south of the United States are entered on this map in tabular form. Pilot-balloon observations are received twice daily from the United States Weather Bureau stations at San Juan, Puerto Rico, and Swan Island in the western Caribbean; also once or twice daily from the naval air stations at Pensacola, Fla.; Guantanamo Bay, Cuba; and Coco Solo, Canal Zone.

P. A. A. pilot-balloon runs are received as follows: Havana, Cienfuegos, and Antilla, Cuba, and Kingston, Jamaica, about one observation a day; San Julian, Cuba; St. Johns, Castries or Fort de France, and Port au Spain, in the Windward Islands; Macoris, in the Dominican Republic, and Merida, Mexico, each about 20 observations per month; Tampico and Vera Cruz or Tejeria, Mexico, and Managua, Nicaragua, about 15 observations per month. David, Panama, and Tacubaya, Hermosillo, Tapachula, Mexico City, and Mazatlan, Mexico, and La Guaira, Venezuela, Barranquillo, Colombo, and Georgetown, British Guiana, are received only occasionally. The locations of these stations are shown in figure 1. While it will be noted that some of these stations are not received regularly, P. A. A. is most cooperative and usually can furnish several special observations daily from any of their stations when a disturbance is in progress. Most P. A. A. observations are taken in the forenoon and usually the number received, except on Sundays, is sufficient to furnish a fair picture of the general upper-air situation.

The increased information concerning upper-air currents now available daily throughout the hurricane season is another of meteorology's debts to aviation. It is hoped that with transoceanic flying regular pilot-balloon ascensions may be made in the not too distant future from a few selected ships located at strategic points. Meanwhile, pilot-balloon stations at St. Georges,[3] Bermuda; Nassau, Bahamas; and on one or more of the outlying Bahama Islands would give the forecaster additional invaluable upper-air information.

The southeast Florida coast, probably one of the most vulnerable sections of the Atlantic and Gulf coasts within the Jacksonville forecast district, and at the same time containing one of the most insistent civic groups upon the question of very precise warnings, presents at times, because of the tendency of tropical storms to recurve in this latitude, certain difficult problems in forecasting. Any consequential further progress in more accurately forecasting recurvatures, in this area at least, can result only through additional pilot-balloon stations as indicated in the preceding paragraph to supplement those now available from the Antilles and Florida.

No upper-air map has yet been printed embracing the area covered by the hurricane warning service. During

[3] Received through courtesy of Pan American Airways from May 1938 to August 1939.

the 4 years since this service was established, the West Indian, Caribbean and Mexican reports have been tabulated in no particular order on the Upper-Air Map A used at Jacksonville, Washington, and other forecast centers. This method, obviously, gives a very unsatisfactory visual presentation of the airflow pattern over the area as a whole. As a makeshift, at Jacksonville, a more suitable map has been mimeographed. This map covers an area bounded on the north by latitude 30°, on the south by latitude 6°, and on the east and west by longitudes 60° and 100°. A number of these maps may be pasted side by side when several levels are desired. mimeographed maps and pasted side by side. Thus, if sufficient reports are available, the forecaster has before him the general airflow pattern in which the tropical storm may be moving.

In the following presentation particular instances of hurricane forecasting wherein aerological data proved useful are discussed with the aid of figures showing the upper winds at the 10,000-foot level. The September 1937 series in the Atlantic is quite simple, while the last two examples are somewhat more complex.

September 3, 1937, a. m., figure 2.—The 10,000-foot level chart on this date presents an approximation of normal

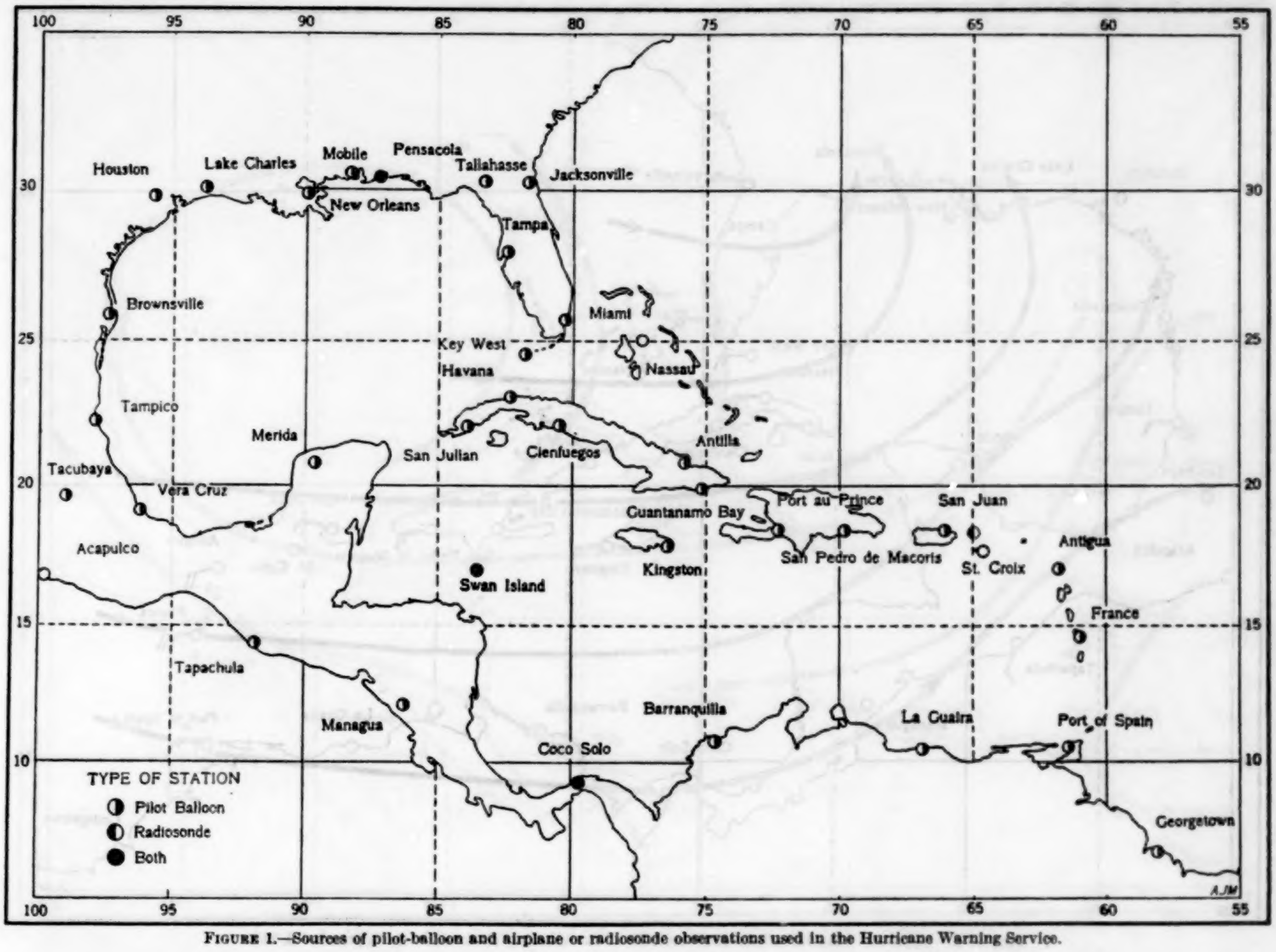

FIGURE 1.—Sources of pilot-balloon and airplane or radiosonde observations used in the Hurricane Warning Service.

During normal weather the tabulated data on Upper-Air Map A are inspected for possible abnormalities in wind velocities and directions. When conditions become unsettled, a 10,000-foot level map is prepared and the airflow pattern determined. The 10,000-foot level has been selected because that level is usually reached by a number of ascents sufficient to indicate with some measure of completeness the high level air currents. However, it has become apparent that at times air currents at still higher levels more closely approximate the direction and rate of movement of certain storms. In addition, the storms usually follow a path somewhat to the right of that indicated by the airflow pattern. When a well-developed tropical storm is in progress, levels at 2,000-foot intervals up to 14,000 feet are prepared on the upper-air conditions at this height for this time of year. East-northeast to east-southeast winds of 10 to 15 miles per hour prevail from near longitude 90° to east of longitude 60°, with a tendency to southeast and south winds west of 90°. Surface weather conditions on this date over the Caribbean Sea and the Gulf of Mexico also are about normal.

September 10, 1937, a. m., figure 3.—The 10,000-foot level chart of this date shows a strong anticyclonic circulation over the Gulf of Mexico, Florida, and Cuba, extending at least as far eastward as longitude 75°. This anticyclonic circulation has strengthened during the past 24 hours and fresh north-northwest winds now obtain over the entire Florida Peninsula. This north-northwest current is indicative of a low pressure trough

at the 10,000-foot level some distance to the eastward, with an attendant southerly counter-current, which would permit a northerly recurve of any storm approaching from the east. At 7:30 a. m. this date a hurricane [4] was located in approximately latitude 21° N. and longitude 57° W. The first advisory on this storm from the Jacksonville district forecast center was issued at 3 p. m. this date, and in the amplification of this advisory to the press the forecaster, on the basis of the upper-air situation plus the general pressure distribution, indicated that the storm offered very little threat to the South Atlantic coast. The next advisory at 9:30 p. m. this same day contained the forecast, based largely on upper air information, as no ship reports close to the storm area had been received since morning, that the hurricane would move north or northeastward during the next few days and would pass to the east of Bermuda. This forecast was substantially verified. Subnormal surface pressure in the region of Bermuda was also indicative of a general northerly movement of this storm.

September 12, 1937, a. m., figure 4.—On this morning's weather chart the hurricane mentioned in the last paragraph was approaching the junction of latitude 30° N. and longitude 60° W., moving north-northwestward, while a second hurricane was central some 900 to 1,000 miles east of Antigua, Leeward Islands, moving only slightly north of west. An examination of the air currents at the 10,000-foot level this date shows a complete break-down of the normal easterly winds over practically the entire area. The only easterly wind encountered is south of latitude 10° at Coco Solo, C. Z. Consequently it is obvious that only an immediate, complete, and radical reversal of the upper-air winds prevailing on this date would permit a continuance of the general westerly movement of this second hurricane. Thus, 2 days before the hurricane reached the eastern limits of the weather map the forecaster was able to formulate an opinion, with considerable confidence, that this storm would make an early recurve.

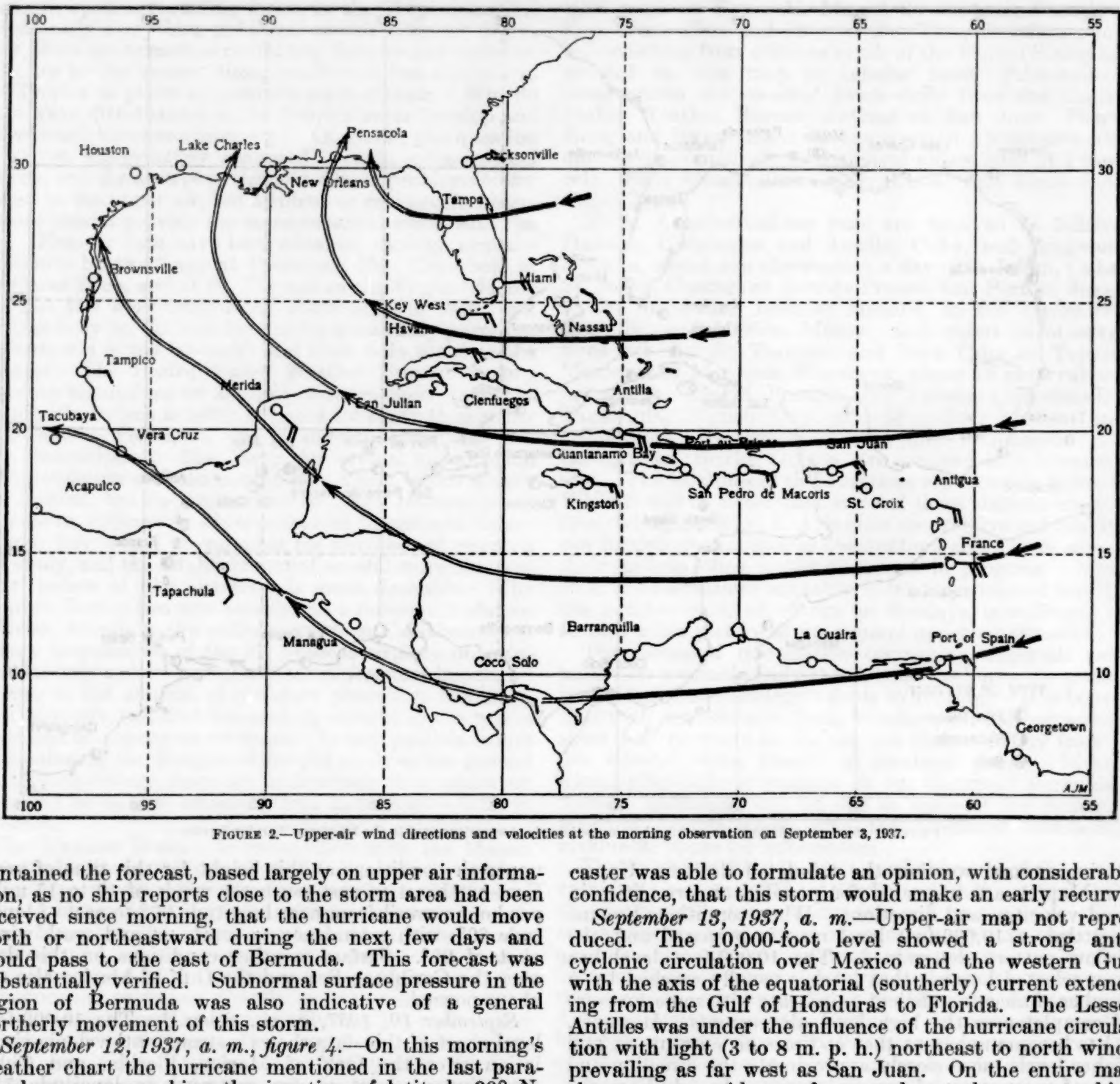

FIGURE 2.—Upper-air wind directions and velocities at the morning observation on September 3, 1937.

September 13, 1937, a. m.—Upper-air map not reproduced. The 10,000-foot level showed a strong anticyclonic circulation over Mexico and the western Gulf with the axis of the equatorial (southerly) current extending from the Gulf of Honduras to Florida. The Lesser Antilles was under the influence of the hurricane circulation with light (3 to 8 m. p. h.) northeast to north winds prevailing as far west as San Juan. On the entire map there was no evidence of any real easterly current which would carry the westward advancing hurricane past longitude 60°.

September 14, 1937, a. m., figure 5.—The hurricane reached its most westward position on this date, whereupon it began a sharp recurve to the east-northeastward.

[4] This storm was classified as definitely not of hurricane intensity in the synopsis of tropical disturbances of 1937, MON. WEATH. REV., December 1937. 65; p. 446. However, the S. S. *Winamac*, while the ship apparently was some distance from the center, reported force 11 (64–75 miles) in an observation radioed to the Jacksonville office. In the writer's opinion the storm was very likely of hurricane intensity for at least 24 hours and should be classified at least of "doubtful" if not of full hurricane intensity.

This direction of movement continued through the 15th, while on the 16th the storm began a north-northeastward movement which lasted for several days and brought it into the far northern latitudes. The 10,000-foot upper air chart on the 14th shows that the anticyclonic circulation continues over the northwestern Gulf, the equatorial break-through persists from Florida southwestward to the Yucatan Peninsula, and that the hurricane circulation is in evidence over the Lesser Antilles. The winds over Jamaica and eastern Cuba are extremely light. The center of the hurricane at 7 p. m. this date was at latitude 19° N. and longitude 58°–59° W., nearly on the eastern border of figure 5. Accepting the 12-mile northeast wind at San Juan as part of the hurricane circulation, one again finds no evidence of a real easterly current aloft west of the hurricane center, and consequently the storm is not subjected to further propulsion toward the west. During this period pressure was flat and somewhat below normal from the Atlantic coast eastward beyond the field of observation. A surface low pressure trough, with an attendant weak cold front through its center, extended from a point about midway between Cape Hatteras and Bermuda southwestward to the Florida Straits. Thus the early and sharp recurve of this hurricane 1,000 miles east of the cold front was not due to the barrier of any surface anticyclone, nor to the approach of a surface low pressure trough, but apparently solely to the wind currents aloft prevailing at the time.

The third hurricane of the month began a recurve to the northwest on the 20th, probably in a southeasterly current aloft. At this time the storm was 1,000 miles east of the Windward Islands and the current in which it moved was too far east to influence the upper air over the Lesser Antilles. Apparently the weakness, or more or less complete disintegration, of the normal easterly current aloft in the lower latitudes, which had permitted early recurves of the two earlier hurricanes was now situated farther to the east. It is thought that the weakening and strengthening of easterly winds aloft over the South Atlantic is associated with the intensity and location of the so-called Azores-Bermuda semipermanent anticyclonic cell. Azores pressures, unfortunately, are not available at the Jacksonville office for study in this connection.

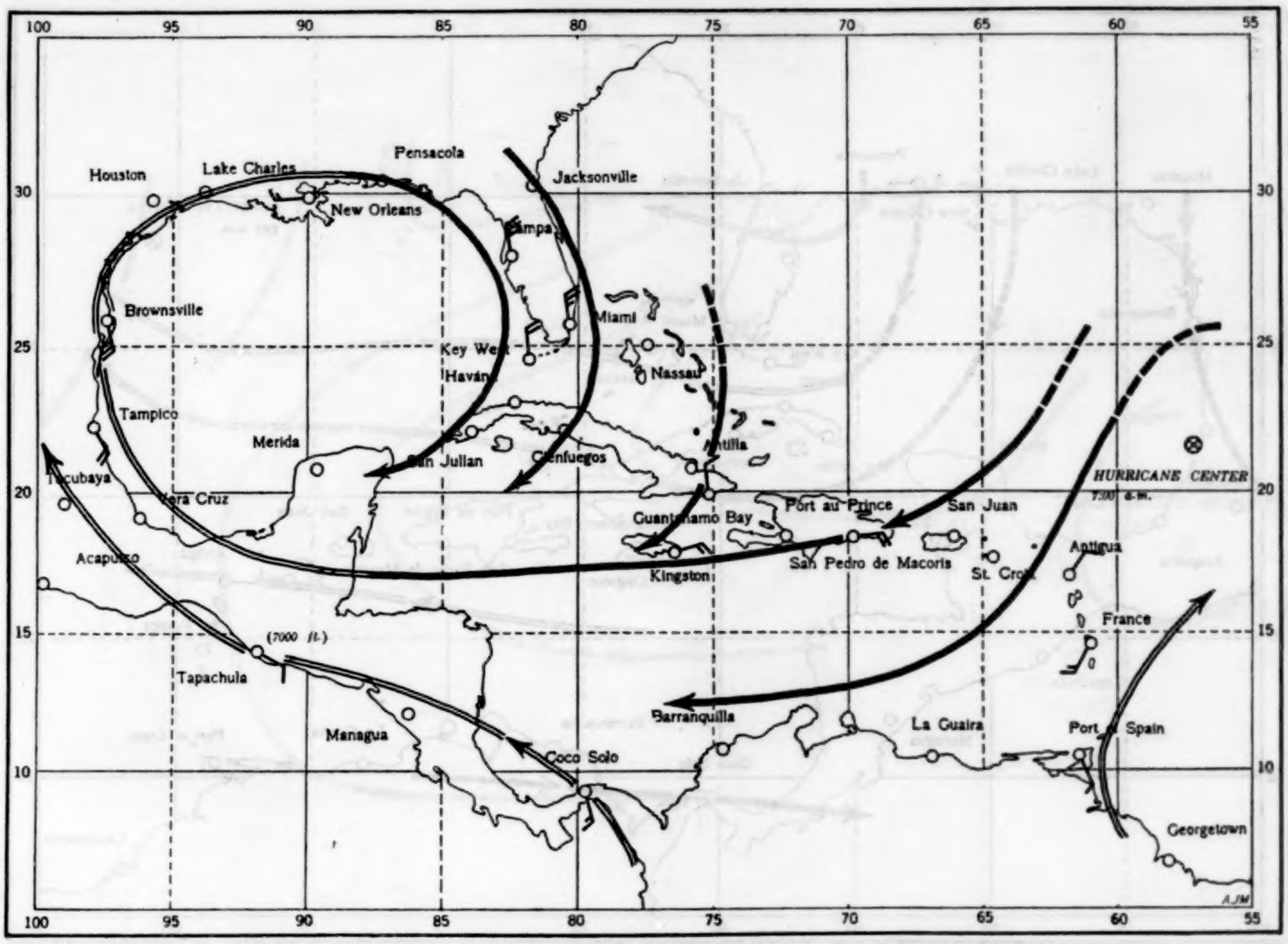

Figure 3.—Upper-air wind directions and velocities at the morning observation on September 19, 1937.

The minor tropical disturbance of September 16–21, 1937, is most interesting and deserves a more intensive study from several standpoints, especially its frontal structure. This storm was a hybrid type, not uncommon in the Gulf of Mexico during September and October, with extra-tropical as well as tropical characteristics. Discussion in this paper, however, will be confined to the aerological situation in regard to this storm on the morning of September 18, 1937.

The first advisory on this disturbance was issued at 10 a. m. on the 17th, but some evidence of a circulation had existed for the preceding 24 hours. During the

16–17th, this storm was located in the southwestern and west-central Gulf, an area relatively unfrequented by weather-reporting vessels. On the morning of the 18th, the forecaster found himself in a rather puzzling situation. Ship reports were confined to the periphery of the disturbance, and as the deadline for the advisory approached the storm's intensity and position had to be obtained by deductions from these peripheral reports. It is also only fair to add that most of the balloon runs outside of the United States were not received until after the advisory was issued. An anticyclone was moving eastward over the Appalachian and Atlantic States and Cuba and western Florida, with east-northeast winds 24–27 miles per hour prevailing at New Orleans, La., and Houston, Tex. Since the storm has moved very slowly during the past 36 hours, it is evident that the tropical storm is not entirely within either the southwesterly current over the southeast Gulf or in the east-northeast current on the Louisiana and Texas coasts, but more probably the two opposite currents are two forces operating upon the storm and that the southwesterly current is the stronger. Although the velocities reported by the several stations in each air stream are about the same, it will be noted that velocities tend to increase as

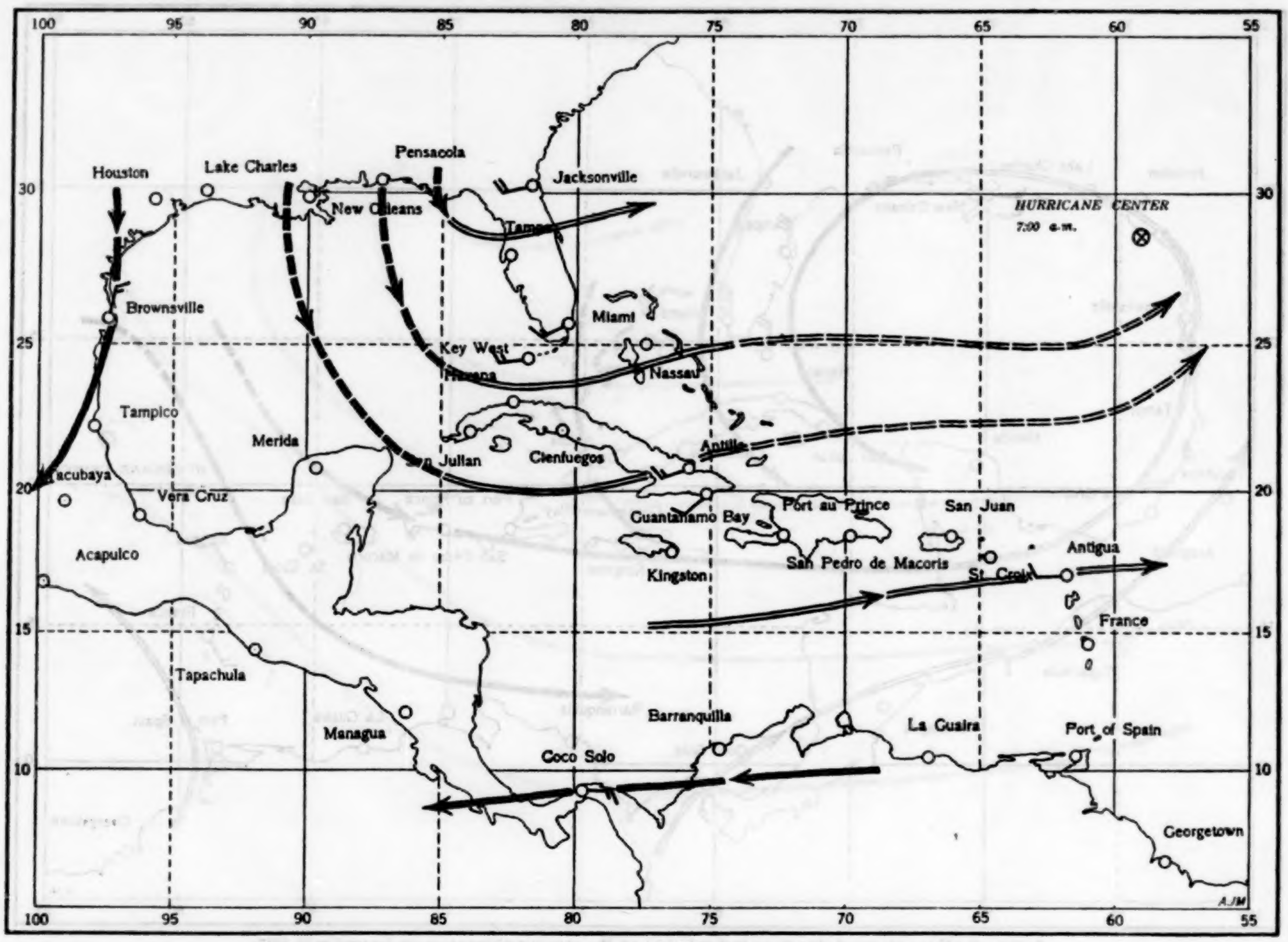

FIGURE 4.—Upper-air wind directions and velocities at the morning observation on September 12, 1937.

the 24-hour pressure fall on the Gulf coast was confined to the area between Brownsville, Tex., and the Mississippi coast. The forecaster finally concluded that the tropical disturbance was showing a slight westward or west-northwestward tendency and storm warnings were extended west of Galveston to Corpus Christi, Tex.

An examination of the upper-air situation at the 10,000-foot level (fig. 6) on the morning of September 18, 1937, discloses an anticyclonic circulation extending from Cuba and surrounding area eastward to Puerto Rico, with a current of southerly component probable over or a short distance east of the Leeward Islands. Over the Gulf of Mexico a deep trough or quasicyclonic circulation prevails with south and southwest winds from 22–28 miles per hour over the Yucatan Peninsula, extreme western the storm area is approached, and it is probable that balloon ascents an equal distance southeast of the storm center would show higher velocities than are reported at New Orleans and Houston. Furthermore, high cloud observations of the Gulf coast show that southwest and west winds are overrunning the east-northeast current prevailing at 10,000 feet, or rather on the west Gulf coast it is the somewhat cooler east-northeast current underrunning the tropical southwest current aloft. Cirrus, cirrostratus, and altostratus from the southwest are reported at Corpus Christi, Galveston, and Port Arthur, Tex., and Lake Charles, La. In fact, no high clouds from any other direction are reported on the Texas coast. At New Orleans, 6/10 altostratus from the east are reported, but as rain was falling it seems probable that

some lower stratotype cloud other than altostratus prevailed. Pensacola, Fla., and Thomasville, Ga., report 10/10 altostratus from the west.

This is a more complex case than any of the previous situations, but whether the east-northeast upper-air current on the northwest Gulf coast is an actual force operating on the storm or merely part of the storm circulation, the integration of all upper-air factors present would seem to indicate a northeastward movement. During the next few days the storm moved northeastward to a point slightly above the mouth of the Mississippi River and thence eastward near the Gulf coast at a rate hurricane should recurve as it approaches this equatorial "break-through" some distance east of the Florida coast. Figure 8 shows the upper air situation at the 10,000-foot level on the morning of the 18th. The wind at Macoris, Dominican Republic, having backed slightly and increased, is now being influenced by the hurricane The winds over southern Florida and western Cuba still have a southerly component, but are backing and decreasing. Over the United States at 10,000 feet above sea level, anticyclonic conditions prevail over the western two-thirds of the country, and at 7 a. m. the southerly limit of the anticyclonic northerly current is a short distance north

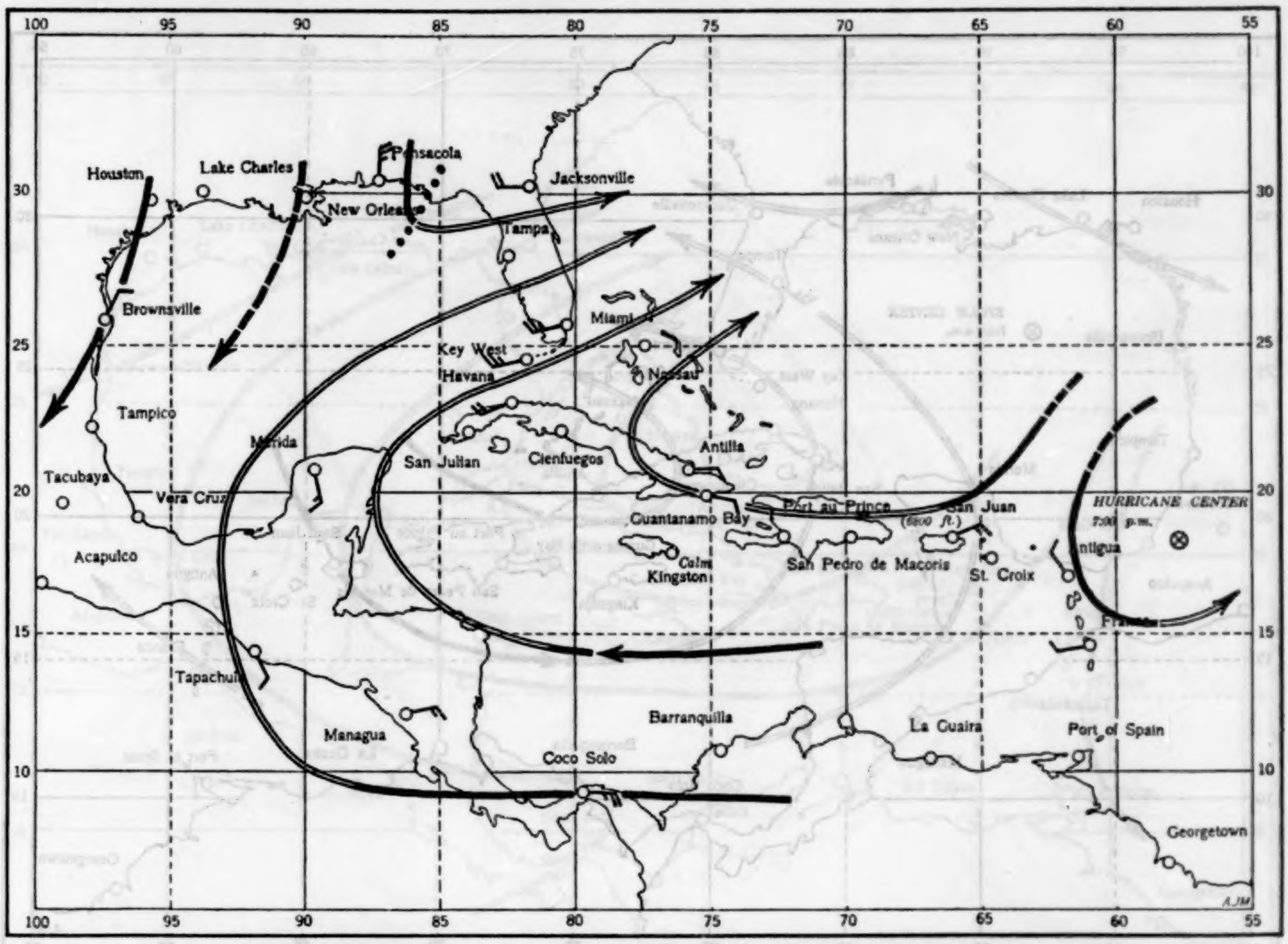

FIGURE 5.—Upper-air wind directions and velocities at the morning observation on September 14, 1937.

of about 6 to 8 miles per hour, and did not at any time reach full hurricane intensity.

The last example of the possible use of upper-air information deals with the severe hurricane of September 17–22, 1938. Figures 7-10 show the 10,000-foot upper-air charts on the mornings of September 17 to 20, from the time the storm was approaching the Bahamas until it began to recurve. The chart (fig. 7) on the morning of September 17 shows an anticyclonic circulation from Antilla, Cuba, eastward, except that the hurricane circulation has begun to affect the Leeward and Windward Islands and probably Puerto Rico. This anticyclonic easterly current is the current in which the hurricane is moving. The equatorial "break-through" covers western Cuba and all of Florida, and the aerological situation as a whole indicates that the of Houston, Tex. From the Appalachians eastward a southwest tropical air current prevails. The general upper air situation still indicates a recurve east of the Florida coast.

The 10,000-foot chart (fig. 9) on the morning of September 19 shows the hurricane circulation extremely well. Winds over western Cuba and extreme southern Florida have backed to northeast and north. As these winds are light and are apparently continuing to back towards the north, one must conclude that they are not an extension of the easterly current in which the hurricane has been traveling, but merely a part of the hurricane circulation. From central Florida northward over the Atlantic States the moist tropical south-southwest air current continues. The anticyclonic circulation noted the day before over the

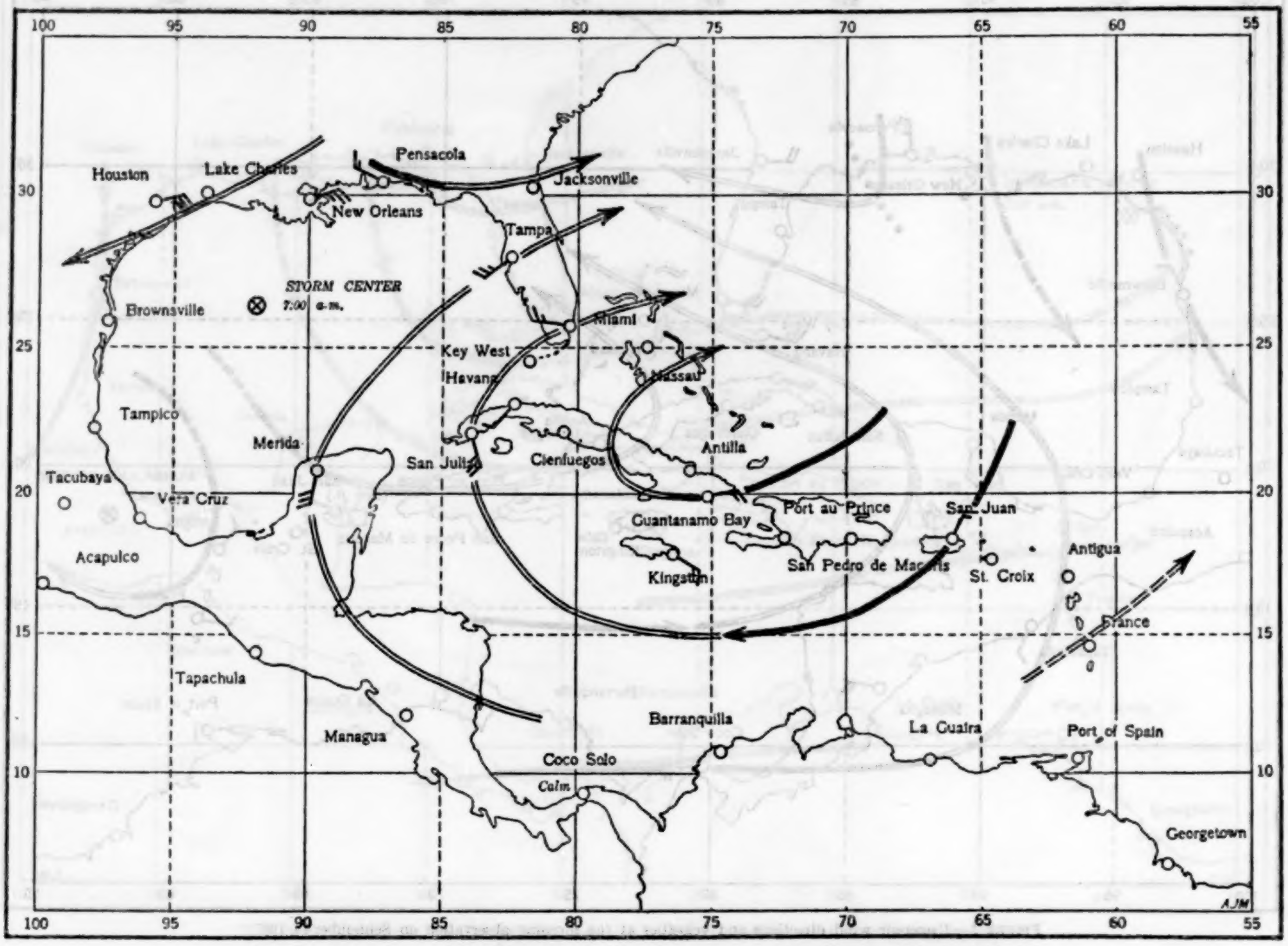

FIGURE 6.—Upper-air wind directions and velocities at the morning observation on September 18, 1937.

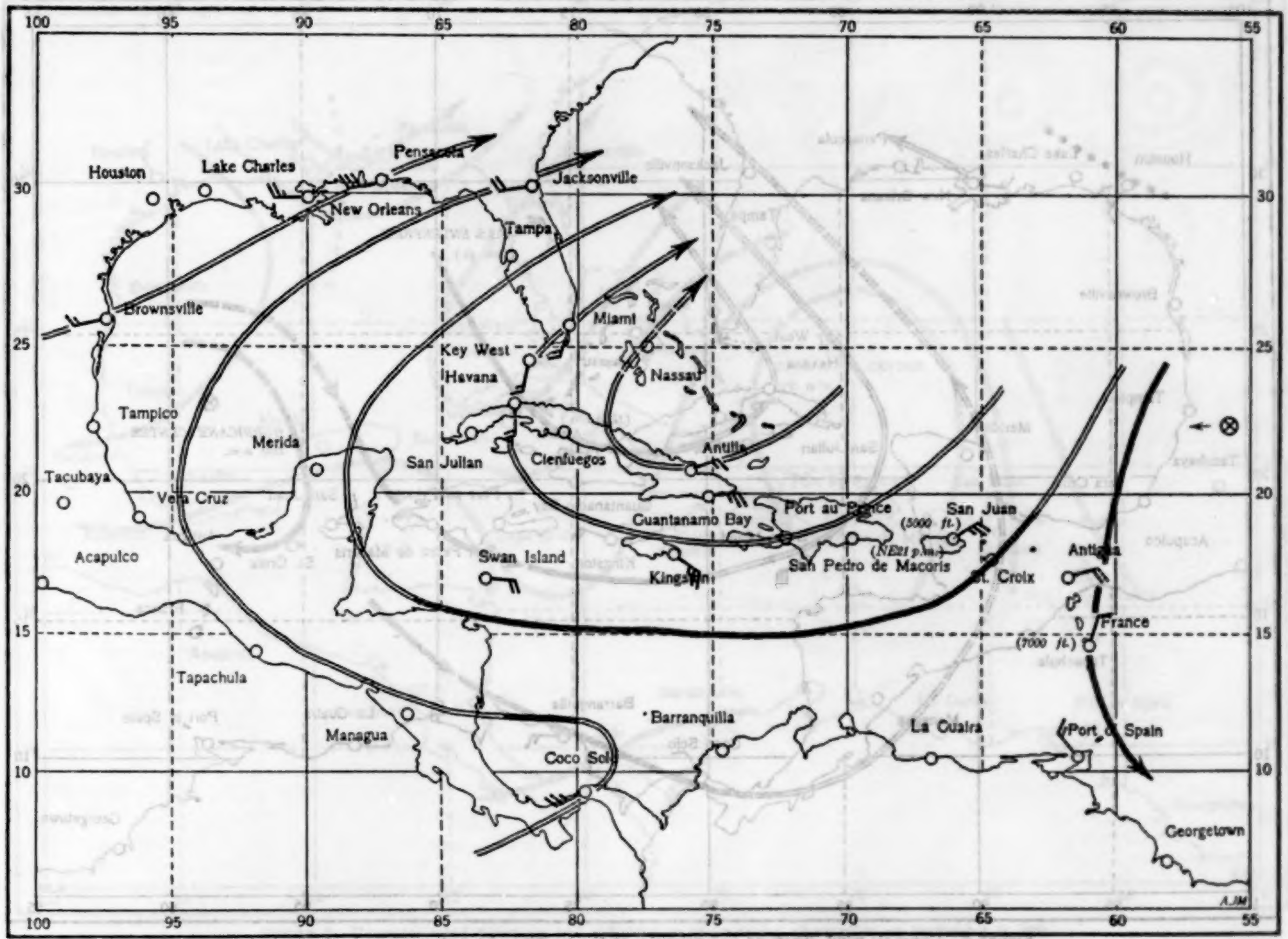

FIGURE 7.—Upper-air wind directions and velocities at the morning observation on September 17, 1938.

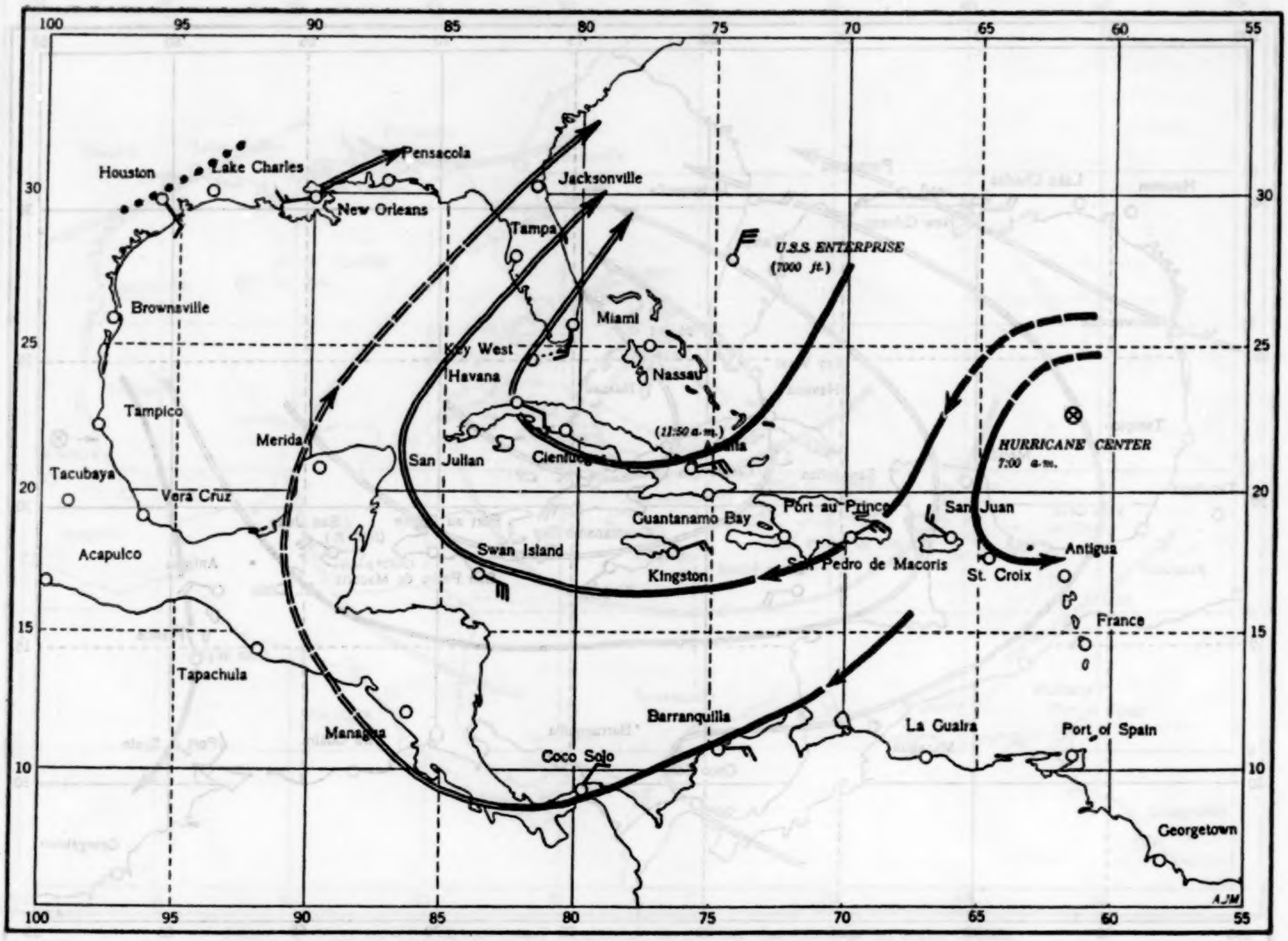

FIGURE 8.—Upper-air wind directions and velocities at the morning observation on September 18, 1938.

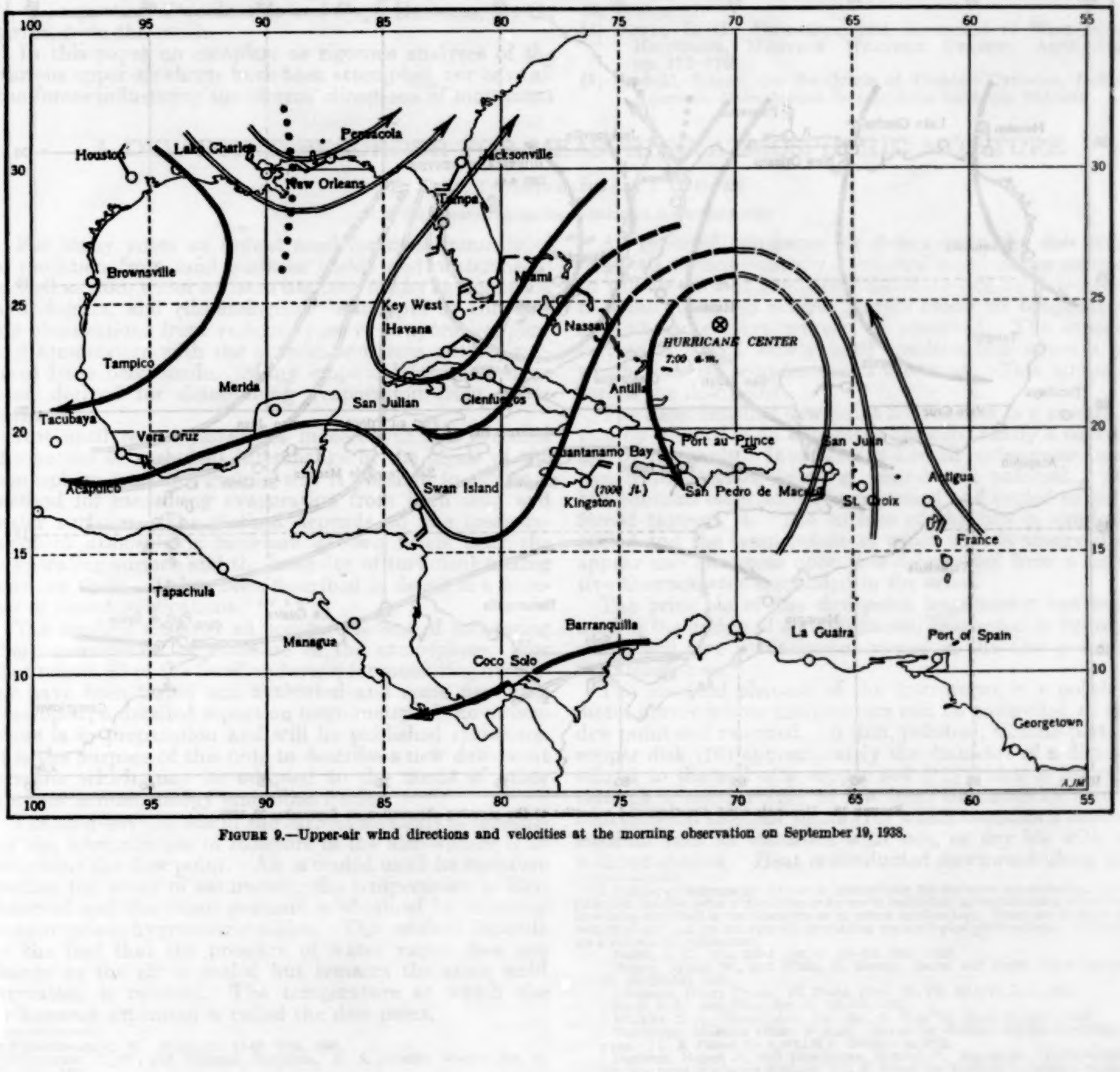

FIGURE 9.—Upper-air wind directions and velocities at the morning observation on September 19, 1938.

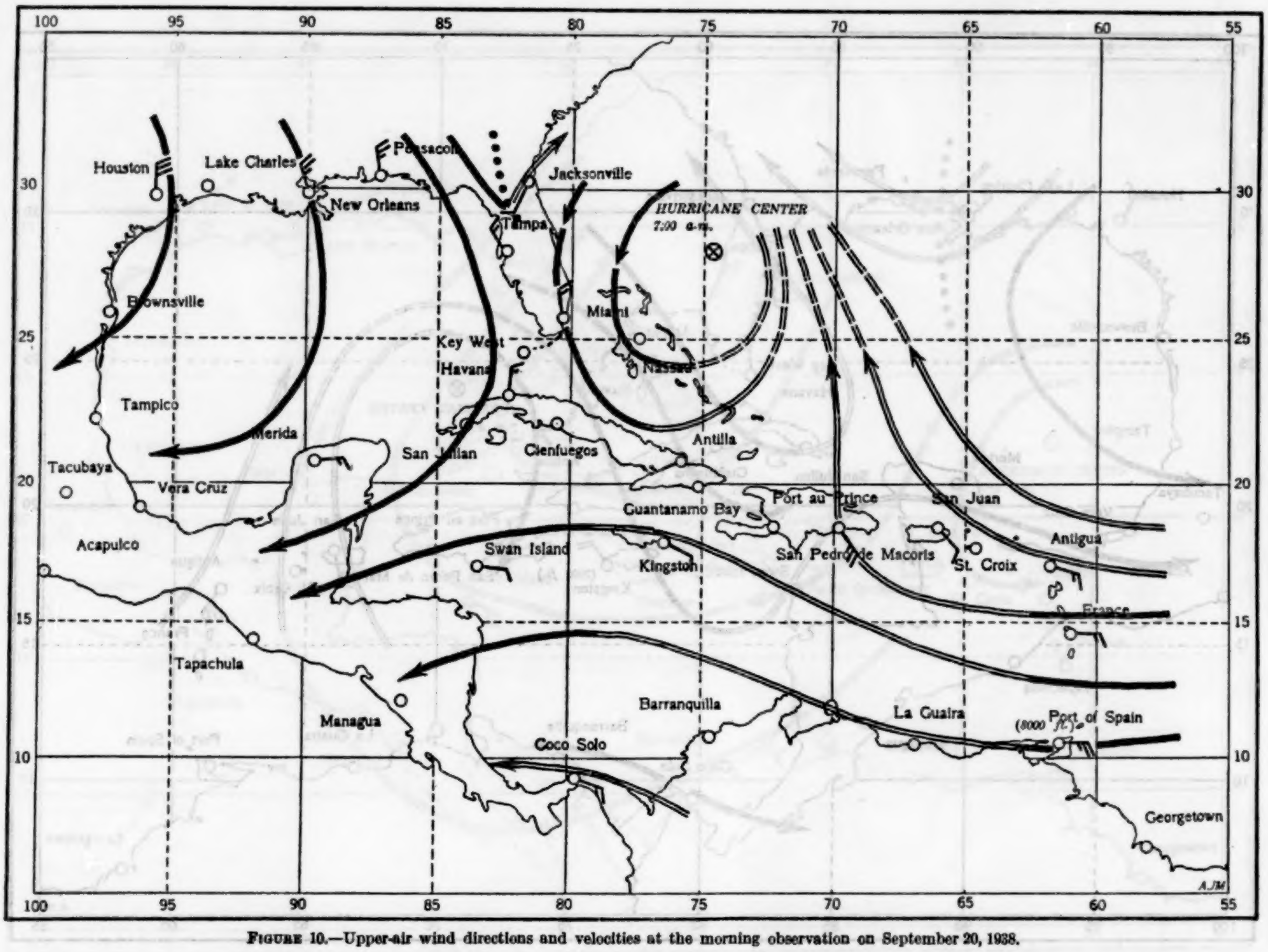

FIGURE 10.—Upper-air wind directions and velocities at the morning observation on September 20, 1938.

western United States has advanced east and south of New Orleans, La. The general aerological situation again indicates a recurve east of the Florida coast.

By the morning of September 20 the hurricane's recurving process from a west-northwest direction to north has almost been completed. The 10,000-foot chart shows conditions are returning to normal over the Windward Islands, while the hurricane circulation has pulled the northerly anticylconic circulation rapidly southeastward during the past 24 hours over the entire eastern Gulf of Mexico, completely wiping out the equatorial salient present there the day before, except near Jacksonville, Fla. Along the Atlantic coast north of Jacksonville, the tropical current remains to a great depth, Charleston, S. C., reporting altoculmulus and Cape Hatteras, N. C., cirrus, from the south.

In this paper no complete or rigorous analyses of the various upper-air charts have been attempted, nor have all the forces influencing the storms' directions of movement been enumerated. Rather, the purpose has been to point out the extent of the aerological information now available in the Tropics or semi-tropics south and east of the United States, and some of the possibilities of the use of pilot-balloon and other upper-air data in the hurricane warning service and the great need of a more comprehensive airplane or radio-meteorograph program in this region.

(1) Calvert, E. B. The Hurricane Warning Service and its Reorganization. National Research Council, *Reports and Papers of the 1935 Meeting of the American Geophysical Union*, pp. 117–121.

(2) Mitchell, C. L. West Indian Hurricanes and Other Tropical Cyclones of the North Atlantic Ocean. MONTHLY WEATHER REVIEW Supplement No. 24, p. 4.

(3) *Ibid*, p. 17.

(4) Bowie, E. H. Formations and Movement of West Indian Hurricanes, MONTHLY WEATHER REVIEW, April 1922, pp. 173–179.

(5) Scofield, Edna. On the Origin of Tropical Cyclones, *Bulletin American Meterological Society*, June 1938, pp. 244–256.

A DEW-POINT RECORDER FOR MEASURING ATMOSPHERIC MOISTURE

By C. W. THORNTHWAITE and J. C. OWEN

[U. S. Soil Conservation Service, Washington, September 5, 1940]

For many years an urgent need for measurements of evaporation from land surfaces (fields and watersheds) as well as from water surfaces has been felt by agronomists, hydrologists, and climatologists. Attempts at correlating observations from various types of evaporation pans and atmometers with the evaporation from natural surfaces have been made. Many empirical formulae have been derived for determining evaporation from water surfaces.

Not until recent researches in aerodynamics revealed the nature of turbulent interchange in the levels of the atmosphere near the ground was it possible to devise a method for measuring evaporation from both land and water surfaces. The method depends on the measurement of atmospheric moisture at two levels near the evaporating surface and the intensity of turbulent mixing between them. It has been described in detail in a number of recent publications.[1 2 3 4 5]

The method required an accurate means of measuring the concentration of moisture in the atmosphere. For that reason all of the familiar devices for measuring humidity have been tested and evaluated and some new ones developed; a detailed report on hygrometry of the atmosphere is in preparation and will be published elsewhere. It is the purpose of this note to describe a new dew-point recorder which may be adapted to the needs of other workers in meteorology and allied fields.

The simplest and one of the earliest methods of measuring the concentration of moisture in the atmosphere is to determine the dew point. Air is cooled until its moisture reaches the point of saturation; the temperature is then observed and the vapor pressure is obtained by referring to appropriate hygrometric tables. This method depends on the fact that the pressure of water vapor does not change as the air is cooled but remains the same until saturation is reached. The temperature at which the air becomes saturated is called the dew point.

All types of apparatus for determining the dew point possess a surface—usually a polished metal mirror exposed to the air so that condensed moisture can be detected—that can be cooled several degrees below air temperature and whose temperature can be observed. The exposed surface is cooled slowly until condensation appears, at which time its temperature is observed. This temperature is the dew point.

The most familiar dew-point hygrometer is a modification by Alluard of an apparatus designed nearly a century ago by Regnault. It consists of a small rectangular metal box whose surface is silver plated and polished. The box contains ether which is vaporized and cooled as air is forced through it. The surface of the box is similarly cooled and the temperature at which dew is observed to appear and disappear upon it is determined from a sensitive thermometer suspended in the ether.

The principle of the dew-point hygrometer has been used in the design of an instrument, illustrated in figure 1, which will give a continuous record of the dew point of the atmosphere.[6]

The essential element of the instrument is a polished metal mirror whose temperature can be controlled at the dew point and recorded. A thin, polished, chrome-plated, copper disk (10) approximately the diameter of a dime is affixed to the end of a copper rod (11) which is inserted through a stopper (12) of low heat conductivity into a conventional thermos bottle (14) which contains a cooling medium such as water-ice with salt, or dry ice with or without alcohol. Heat is conducted downward along the

[1] Thornthwaite, C. W. *Ecology* 21: 17–28, illus., 1940.

[2] Thornwaite, C. W., and Holzman, Benjamin. *U. S. Monthly Weather Rev.* 67: 4-11, illus., 1939.

[3] Thornthwaite, C. W., and Holzman, Benjamin. *Natl. Res. Council, Amer. Geophys. Union Trans., Ann. Meeting* 20: 680–686, illus., 1939.

[4] Thornthwaite, C. W., and Holzman, Benjamin. *Natl. Res. Council, Amer. Geophys. Union Trans., Ann. Meeting* 21: 510–511, 1940.

[5] Thornthwaite, C. W., and Holzman, Benjamin. *U. S. Dept. Agr. Yearbook 1941*. [In press.]

[6] A number of instruments for use in determining the moisture concentration of flue gases and the dew point of distillates or for use in controlling air-conditioning equipment have been described in the literature or in patent applications. They are designed for industrial uses and are not suitable for making meteorological observations. Following are a few selected references:

Frank, A. K. *Gen. Elect. Rev.* 41: 435–437, illus., 1938.

Hixson, Arthur W., and White, G. Edwin. *Indus. and Engin. Chem. Analyt. Ed.* 10: 235–240, 1938.

Johnstone, Henry Fraser. *Ill. Engin. Expt. Sta. Cir.* 20: 5–22, illus., 1929.

Stack, S. S. *Gen. Elect. Rev.* 41: 106–108, 1938.

Winkler, C. A. *Canad. Jour. Res. Sect. D, Zool. Sci.* 17: 35–38, illus., 1939.

Tomlinson, Malcolm Claire Weyant. Device for determining the condition of a gas. *(U. S. Patent No. 1,883,116.)* October 18, 1932.

Deniston, Robert F., and Hawthorne, Wendell P. Apparatus for determining the dew point of a vapor product. *(U. S. Patent No. 2,106,595.)* January 25, 1938.

Anderson, Samuel M. Fluid-conditioning method and apparatus. *(U. S. Patent No. 1,789,268.)* January 13, 1931.

Johnson, James Yate. Improvements for measuring the humidity of gases or gaseous mixtures. *(British Patent No. 317,306.)* August 12, 1929.

Griffiths, Ezer, and Campbell, Norman Robert. Improvements for hygrometric apparatus. *(British Patent No. 330,778.)* June 19, 1930.

copper rod and the mirror is cooled. Embedded into the end of the rod directly beneath the mirror is a small electrical heating element (16) which counteracts the flow of heat from the mirror when the circuit is closed. Light from an incandescent bulb (17) is reflected from the surface of the mirror to a photoelectric cell (18). The electric current generated by the photoelectric cell operates a sensitive relay which in turn energizes a power relay (19), whereby a switch (20) is opened against the action of a spring (21), preventing the operation of the heating element (16) beneath the mirror.

Heat from the mirror is conducted along the rod until moisture from the surrounding atmosphere condenses on varying only slightly above and below as it is alternately heated and cooled. The temperature is determined by means of a thermocouple, the cold junction of which is a part of the mirror and the warm junction maintained at a standard temperature. Any standard electrical recorder may be used to obtain a record of the dew point.

For use in the dew-point instrument a photographic recorder has certain points of superiority over one which operates electrically. The thermocouple is connected through a galvanometer. A light beam, reflected by the galvanometer mirror, is directed through a slot onto sensitized photographic paper which revolves on a drum or cylinder. A switch in the light circuit is attached to the

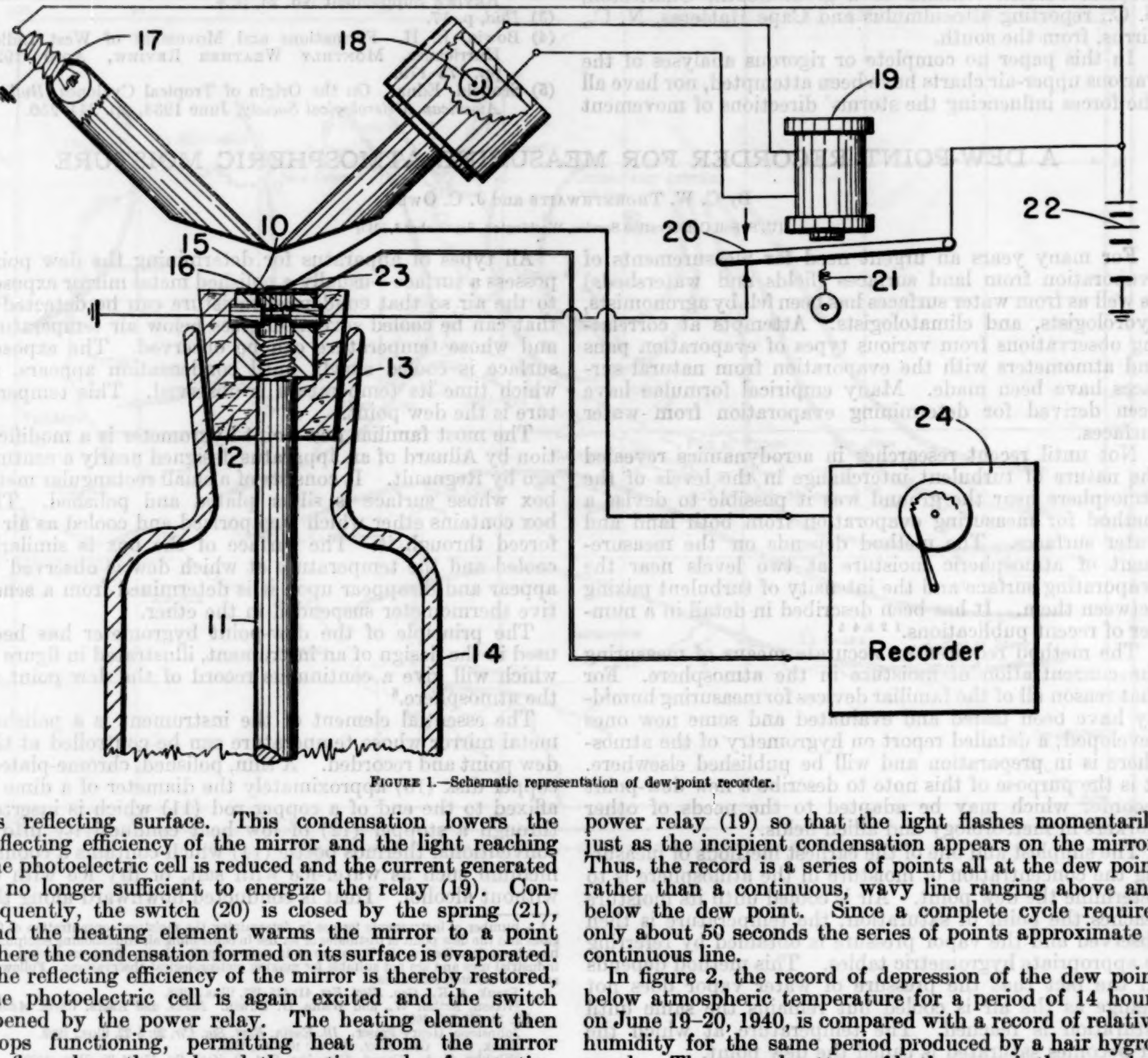

FIGURE 1.—Schematic representation of dew-point recorder.

its reflecting surface. This condensation lowers the reflecting efficiency of the mirror and the light reaching the photoelectric cell is reduced and the current generated is no longer sufficient to energize the relay (19). Consequently, the switch (20) is closed by the spring (21), and the heating element warms the mirror to a point where the condensation formed on its surface is evaporated. The reflecting efficiency of the mirror is thereby restored, the photoelectric cell is again excited and the switch opened by the power relay. The heating element then stops functioning, permitting heat from the mirror to flow along the rod and the entire cycle of operation is repeated.

A mere film of moisture on the mirror, invisible to the eye, is sufficient to reduce the output of the photoelectric cell by 10 microamperes, which is the range within which a sensitive relay will operate. Consequently, the temperature of the mirror remains very close to the dew point, power relay (19) so that the light flashes momentarily just as the incipient condensation appears on the mirror. Thus, the record is a series of points all at the dew point rather than a continuous, wavy line ranging above and below the dew point. Since a complete cycle requires only about 50 seconds the series of points approximate a continuous line.

In figure 2, the record of depression of the dew point below atmospheric temperature for a period of 14 hours on June 19–20, 1940, is compared with a record of relative humidity for the same period produced by a hair hygrograph. The general pattern of both curves is the same but the much greater sensitivity and greater degree of refinement of the dew-point record is apparent.

The instrument described above employs mechanical relays for opening and closing the circuit to the heater that is beneath the mirror. It is, of course, entirely feasible to use an electrical circuit in which radio tubes

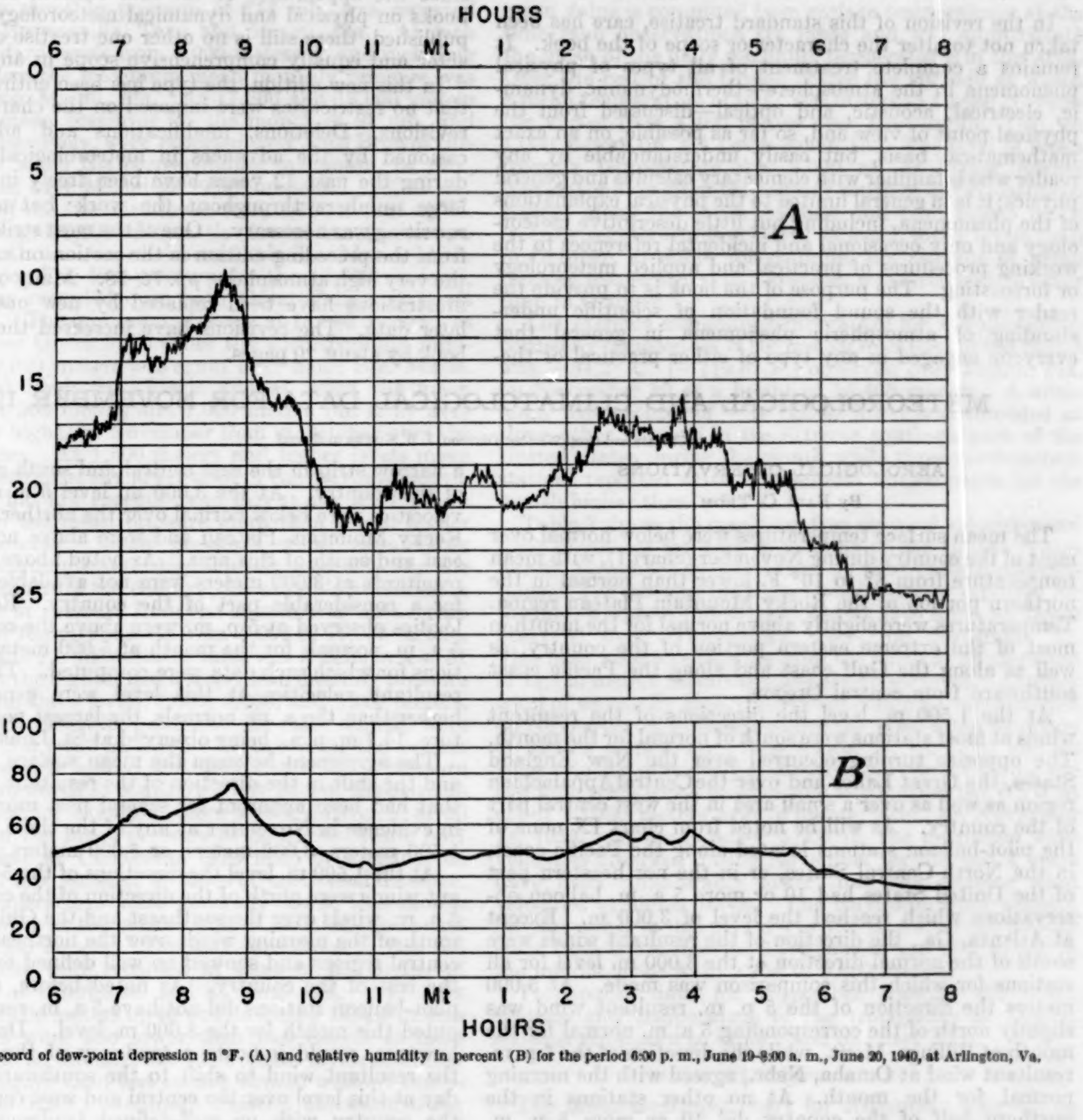

FIGURE 2.—Record of dew-point depression in °F. (A) and relative humidity in percent (B) for the period 6:00 p. m., June 19–8:00 a. m., June 20, 1940, at Arlington, Va.

replace mechanical relays. In fact, by means of radio tubes it should be possible to build a circuit such that the current to the heater varies inversely as the reflective quality of the mirror. Then as moisture begins to appear on the mirror the heat applied to it will increase and the temperature of the mirror will be maintained continuously at the dew point, or at a level that bears a constant relation to it.

NOTES AND REVIEWS

W. J. HUMPHREYS. *Physics of the Air.* 3d edition. New York (McGraw-Hill Book Co.), 1940. 676 pp., 226 figs.

In the revision of this standard treatise, care has been taken not to alter the character or scope of the book. It remains a complete treatment of all types of physical phenomena in the atmosphere—thermodynamic, dynamic, electrical, acoustic, and optical—discussed from the physical point of view and, so far as possible, on an exact mathematical basis, but easily understandable by any reader who is familiar with elementary calculus and general physics; it is in general limited to the physical explanations of the phenomena, including but little descriptive meteorology and only occasional and incidental references to the working procedures of practical and applied meteorology or forecasting. The purpose of the book is to provide the reader with the sound foundation of scientific understanding of atmospheric phenomena in general that everyone engaged in any type of either practical or theoretical meteorological work should have; and although, since the appearance of the first edition, several other books on physical and dynamical meteorology have been published, there still is no other one treatise of like character and equally comprehensive scope in any language.

In this new edition, the type has been entirely reset, so that no restrictions were imposed on the character of the revisions. Deletions, modifications and additions occasioned by the advances in meteorological knowledge during the past 12 years have been freely introduced in large numbers throughout the work; but no extensive rewriting was necessary. One of the most striking changes from the preceding edition is the section on conditions in the very high atmosphere, pp. 75–78. Many of the former illustrations have been replaced by new ones based on later data. The revisions have increased the size of the book by about 20 pages.

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR NOVEMBER 1940

[Climate and Crop Weather Division, J. B. KINCER in charge]

AEROLOGICAL OBSERVATIONS

By EARL C. THOM

The mean surface temperatures were below normal over most of the country during November (chart I), with mean temperature from 8° to 10° F. lower than normal in the northern portion of the Rocky Mountain Plateau region. Temperatures were slightly above normal for the month in most of the extreme eastern portion of the country, as well as along the Gulf coast and along the Pacific coast southward from central Oregon.

At the 1,500 m. level the directions of the resultant winds at most stations were south of normal for the month. The opposite turning occurred over the New England States, the Great Lakes and over the Central Appalachian region as well as over a small area in the west central part of the country. As will be noted from chart IX none of the pilot-balloon stations located along the Pacific coast, in the North Central States, or in the northeastern part of the United States had 10 or more 5 a. m. balloon observations which reached the level of 3,000 m. Except at Atlanta, Ga., the direction of the resultant winds were south of the normal direction at the 3,000 m. level for all stations for which this comparison was made. At 5,000 meters the direction of the 5 p. m. resultant wind was slightly north of the corresponding 5 a. m. normal for the month at Billings, Mont., while the direction of the 5 p. m. resultant wind at Omaha, Nebr., agreed with the morning normal for the month. At no other stations in the northern half of the country did 10 or more 5 p. m. balloon observations reach 5,000 meters during the month (see chart X). In the southern half of the country the directions of the 5 p. m. resultant winds were north of the corresponding 5 a. m. normals along the Pacific coast and were south of these normals to the eastward.

The 5 a. m. resultant velocities at 1,500 meters were lower than normal for the month, except that small positive departures occurred in the extreme northwest and in a narrow strip in the east central and south central parts of the country. At the 3,000 m. level 5 a. m. resultant velocities were below normal over the northern half of the Rocky Mountain Plateau and were above normal to the east and south of this area. As noted above, the 5 a. m. resultants at 3,000 meters were not available this month for a considerable part of the country. Resultant velocities observed at 5 p. m. were above the corresponding 5 a. m. normals for the month at 5,000 meters at all stations for which such data were computed. The afternoon resultant velocities at this level were generally much higher than the a. m. normals, the largest positive departure, 14.7 m. p. s., being observed at St. Louis, Mo.

The agreement between the mean surface temperature and the shift in the direction of the resultant from normal that had been apparent for several past months was not in evidence in November at any of the three lower levels, 1,500 meters, 3,000 meters, or 5,000 meters.

At the 1,500 m. level the directions of the 5 p. m. resultant winds were north of the direction of the corresponding 5 a. m. winds over the southeast and the Gulf coast, were south of the morning winds over the northeast and north central regions and showed no well defined tendency over the rest of the country. As noted before, a number of pilot-balloon stations did not have 5 a. m. resultants computed this month for the 3,000 m. level. Data available, however, would indicate a tendency of the direction of the resultant wind to shift to the southward during the day at this level over the central and west central parts of the country with no well-defined tendency over other areas.

The 5 p. m. resultant velocities for the month were higher than the corresponding 5 a. m. velocities at 1,500 meters along the Pacific coast and the northern half of the Atlantic coast and were lower than the morning velocities over most of the remainder of the country. At 3,000 meters the increases and decreases in resultant velocity from 5 a. m. to 5 p. m. were well distributed.

The upper-air data discussed above are based on 5 a. m. observations (charts VIII and IX) as well as on observations made at 5 p. m. (table 2, and charts X and XI).

The highest mean monthly pressure recorded at the 1,500 m. level by the raob and apob reporting stations of the United States was 856 mb. reported over both Pensacola, Fla. and Miami, Fla. At 2,000 and 2,500 meters the maximum mean pressure for the month was reported over Miami, Fla., while at 3,000 meters a maximum mean monthly pressure of 714 mb. was reported over both Brownsville, Tex., and Miami, Fla. At each of the standard levels from 4,000 meters to and including 16,000 meters the maximum mean monthly pressure was reported over Miami, Fla. At 17,000 and 18,000 meters maximum mean pressures for the month of 91 mb. and 77 mb., respectively, were reported over both Brownsville and Miami while the corresponding maximum, 64 mb., was recorded over Miami at 19,000 meters.

At each of the standard levels from 1,500 meters up to, and including, 16,000 meters the lowest mean pressure for the month was recorded over Sault Ste. Marie, Mich. The corresponding low pressure for the 17,000 m. level, 84 mb., was recorded over both Great Falls and Sault Ste. Marie. The minimum pressure at 18,000 meters was recorded over Great Falls while the corresponding minimum for 19,000 meters was again over Sault Ste. Marie.

Except at Sault Ste. Marie and at Joliet the mean pressures at 500 meters and 1,000 meters (m. s. l.) were the same or higher in November than in October over the United States. At 1,500 meters and higher levels mean pressures were generally lower than in the previous month. There were but few exceptions to this at any level and in no case was the mean pressure more than 1 mb. higher than in October. Mean pressures were considerably lower than last month at the higher levels, especially over the north central part of the country, for example at Bismarck the decrease in pressure from last month was an average of 11 mb. for the seven levels from 5,000 to 11,000 meters.

For the entire United States there was a difference of 31 mb. between the highest and lowest mean monthly pressure at each of the three levels, 7,000, 8,000, and 9,000 meters. The steepest pressure gradients for the month were recorded at the 7,000 m. level. At this level the isobars were quite evenly spaced and indicated a steep pressure gradient from north to south over any part of the extreme eastern states, for example, there was a difference of 25 mb. between the mean pressure at Sault Ste. Marie (401 mb.) and that at Charleston (426 mb.) or a change in pressure of 1 mb. for each 40 miles of horizontal distance.

Mean temperatures were generally lower this month than in October at the surface and at all levels up to and including 7,000 meters. The only exceptions to this fall in temperature were recorded at some of the higher of these levels at Charleston and at Pensacola. At all six levels from 8,000 meters up to and including 13,000 meters temperatures were also lower than last month at most stations while at the next six 1,000 meter levels temperatures were higher than last month almost without exception from the Rocky Mountain Plateau eastward to the Mississippi and were lower at these levels over the rest of the country.

Mean monthly temperatures for November this year were lower than the corresponding November temperatures last year at all levels above the surface and up to 5,000 meters over the western part of the United States and over the northern half of the Central States including most of the Great Lakes region. Temperatures were generally higher than last year at these levels over the rest of the country. At higher levels the eastern half of the country was warmer than last year at levels from 7,000 meters to about 12,000 meters and then cooler than last year up to 17,000 meters. Corresponding temperature tendencies at levels above 5,000 meters were not well defined over the western part of the country.

The mean surface temperature for the month of November as reported by raob stations (table 1) was below freezing over the northern Great Lakes, the extreme north central states and over most of the Rocky Mountain and Plateau region north of about 38° N. latitude. This mean value is computed from surface temperatures at the time raob observations are made and will approximate the mean of the daily minimum temperatures in this area. Over the rest of the United States the altitude at which a mean temperature of 0° C .was observed during November varied from 4,400 meters over Brownsville, Tex., to 1,000 meters (m. s. l.) over Joliet, Ill. The level of mean freezing temperature was 3,000 m. or higher during November over all of the country south of 35° N. latitude. Except along the south Atlantic and Gulf coasts mean freezing temperatures occurred at much lower levels than in October, at Joliet for example, the altitude of mean freezing temperatures in November was 2,100 meters lower than in October.

The extreme minimum temperature for the month recorded by radiosondes in the free air over the United States was −84.2° C. (−119.6° F.) observed over Miami, Fla. on November 30 at a height of 16,400 meters. A minimum temperature of −80° C. or lower was recorded at three other stations in the extreme southern part of the United States during the month while three northeastern stations reported extreme minimum temperatures for the month higher than −70° C.

Table 3 shows the maximum free-air wind velocities and their directions for various sections of the United States during November as determined by pilot-balloon observations. The extreme maximum wind velocity reported for the month was 98.4 meters per second (220 miles per hour) observed over Winnemucca, Nev., on November 22. This high wind was blowing from the north at an elevation of 11,120 meters (about 7 miles) above sea level. Another wind of unusually high velocity (97.8 m.p.s.) was reported on November 26 as blowing from the West at an elevation of 12,014 meters over Greensboro, N. C. The highest wind velocity previously reported in November during the last four years was a wind of 90.0 m.p.s. from the WSW at about 12,000 meters over Winslow, Ariz., on November 14, 1938. At levels below 5,000 m. the maximum wind velocities observed during November for the past 4 years have been considerably lower than the extreme wind velocities at higher levels. The maximum wind velocity for November in this period was 55.8 m.p.s. for the free-air layer from the surface to 2,500 meters and 69.1 m.p.s. in the middle levels from 2,500 to 5,000 meters.

Tropopause data for November showing the mean altitude and temperature of the tropopause at various stations are shown in table 4 and on chart XIII.

MEAN ISENTROPIC CHART [1]

The mean isentropic chart for November suggests no significant correlations with the weather of the month. This is in part due to the wide variance in circulation patterns during the month, with slow-moving systems and extensive north and south movements of warm moist and cold dry air, respectively, near the middle of the month and rapid west to east movement near the end of the month.

The change from the previous month reflects the normal seasonal trend toward more active westerlies farther to the south with less opportunity for persistent vortices to develop over the continental United States.

[1] Prepared by A. K. Showalter, Hydrometeorological Section.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during November 1940*

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Anchorage, Alas. (41 m.)				Bismarck, N. Dak. (505 m.)				Brownsville, Tex. (6 m.)				Charleston, S. C. (14 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	1,006	−4.4	80	30	960	−5.9	83	26	1,018	18.6	87	30	1,020	11.0	88
500	30	950	−2.8	73	-----	-----	-----	-----	26	962	17.7	83	30	963	12.8	72
1,000	30	891	−3.5	71	30	901	−4.9	77	26	907	14.9	82	30	907	10.9	68
1,500	30	836	−5.6	69	30	846	−3.9	73	26	855	12.7	77	30	854	8.5	64
2,000	30	784	−7.8	69	30	793	−4.6	69	26	805	11.2	67	30	803	6.8	59
2,500	30	735	−10.4	65	30	745	−6.0	65	26	758	9.4	64	30	756	5.2	54
3,000	30	689	−13.3	62	30	698	−8.4	62	26	714	7.8	57	30	711	3.6	44
4,000	30	603	−19.8	59	30	613	−14.8	60	26	632	2.6	53	30	628	−1.0	40
5,000	30	526	−26.9	58	30	536	−21.4	59	26	558	−3.6	49	29	553	−6.5	42
6,000	29	457	−33.9	57	30	467	−27.7	59	26	491	−10.0	42	29	486	−12.7	41
7,000	27	395	−41.1	-----	30	406	−34.8	58	26	430	−16.5	39	29	426	−19.3	40
8,000	27	340	−47.9	-----	29	350	−42.2	-----	26	376	−23.5	39	27	371	−26.2	40
9,000	27	292	−53.3	-----	29	302	−49.1	-----	26	327	−30.5	37	27	322	−33.4	40
10,000	25	250	−55.4	-----	29	259	−54.2	-----	25	284	−38.0	34	26	279	−40.9	-----
11,000	25	214	−55.6	-----	29	221	−56.5	-----	25	245	−46.0	-----	26	240	−48.1	-----
12,000	25	182	−54.3	-----	29	189	−56.3	-----	25	210	−53.8	-----	26	206	−54.0	-----
13,000	21	156	−53.4	-----	29	161	−56.2	-----	25	179	−61.3	-----	26	176	−60.7	-----
14,000	19	134	−53.4	-----	29	138	−56.9	-----	25	152	−68.1	-----	26	149	−65.3	-----
15,000	17	114	−53.4	-----	27	117	−57.9	-----	24	128	−73.0	-----	25	126	−68.3	-----
16,000	14	98	−53.6	-----	24	100	−58.6	-----	24	108	−75.3	-----	24	107	−70.9	-----
17,000	12	84	−54.2	-----	22	85	−58.9	-----	22	91	−74.5	-----	21	90	−71.7	-----
18,000	8	71	−54.7	-----	13	73	−59.0	-----	17	77	−70.5	-----	16	76	−70.6	-----
19,000	-----	-----	-----	-----	7	62	−59.4	-----	12	65	−65.0	-----	15	64	−67.7	-----
20,000	-----	-----	-----	-----	-----	-----	-----	-----	8	55	−60.8	-----	6	54	−65.6	-----

Altitude (meters) m. s. l.	Coco Solo, C. Z.[1] [2] (15 m.)				Denver, Colo. (1,616 m.)				El Paso, Tex. (1,193 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	17	1,012	25.8	90	30	839	−1.2	70	30	884	7.7	60
500	17	956	24.0	84	-----	-----	-----	-----	-----	-----	-----	-----
1,000	17	903	20.9	80	-----	-----	-----	-----	-----	-----	-----	-----
1,500	17	852	18.2	73	-----	-----	-----	-----	30	853	9.7	60
2,000	17	803	15.3	70	30	799	+2.4	68	30	802	7.6	54
2,500	15	757	12.8	55	30	751	0.0	63	30	755	5.2	50
3,000	14	713	10.3	52	30	705	−3.2	62	30	710	2.5	47
4,000	8	632	4.2	44	30	621	−9.8	62	30	627	−3.3	45
5,000	-----	-----	-----	-----	30	544	−15.6	57	30	552	−9.9	43
6,000	-----	-----	-----	-----	30	476	−22.2	52	30	484	−16.4	39
7,000	-----	-----	-----	-----	29	414	−29.3	50	30	423	−22.8	36
8,000	-----	-----	-----	-----	29	360	−36.7	50	29	368	−29.7	35
9,000	-----	-----	-----	-----	29	310	−44.7	-----	29	319	−36.7	34
10,000	-----	-----	-----	-----	28	267	−51.4	-----	27	276	−44.4	-----
11,000	-----	-----	-----	-----	28	228	−55.6	-----	26	237	−51.8	-----
12,000	-----	-----	-----	-----	28	195	−57.6	-----	24	202	−57.3	-----
13,000	-----	-----	-----	-----	27	166	−58.9	-----	21	172	−61.7	-----
14,000	-----	-----	-----	-----	24	142	−61.0	-----	20	147	−66.6	-----
15,000	-----	-----	-----	-----	23	121	−62.8	-----	20	124	−68.1	-----
16,000	-----	-----	-----	-----	21	102	−63.6	-----	19	105	−66.9	-----
17,000	-----	-----	-----	-----	18	87	−63.3	-----	17	89	−65.8	-----
18,000	-----	-----	-----	-----	13	74	−62.9	-----	13	76	−63.3	-----
19,000	-----	-----	-----	-----	8	62	−61.8	-----	10	64	−60.7	-----
20,000	-----	-----	-----	-----	-----	-----	-----	-----	5	55	−58.7	-----

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Ely, Nev. (1,908 m.)				Great Falls, Mont. (1,117 m.)				Joliet, Ill. (178 m.)				Juneau, Alaska (49 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	811	−2.9	69	30	890	−3.5	74	30	998	1.3	85	27	1,010	1.0	66
500	-----	-----	-----	-----	-----	-----	-----	-----	30	959	0.9	84	27	954	−2.2	66
1,000	-----	-----	-----	-----	-----	-----	-----	-----	30	901	0.0	78	27	896	−5.0	69
1,500	-----	-----	-----	-----	30	849	−2.2	69	30	846	−0.9	72	26	840	−6.9	72
2,000	30	802	−0.8	66	30	796	−4.2	67	30	794	−2.5	69	22	786	−8.8	73
2,500	30	754	−0.8	58	30	747	−6.1	66	30	746	−4.6	66	22	738	−10.9	72
3,000	30	708	−3.1	55	30	709	−9.4	67	30	700	−6.8	64	22	691	−14.0	68
4,000	30	623	−8.6	50	30	615	−15.6	67	30	615	−12.3	57	22	605	−20.6	62
5,000	30	547	−14.6	46	30	538	−22.0	62	30	539	−18.3	53	20	528	−27.5	56
6,000	30	478	−21.7	44	30	469	−29.3	60	29	470	−24.9	51	20	458	−34.6	51
7,000	30	417	−28.3	43	30	406	−36.2	58	28	409	−32.1	51	18	396	−41.6	-----
8,000	30	362	−35.5	43	30	351	−43.6	-----	25	354	−39.1	51	17	341	−48.7	-----
9,000	30	313	−42.8	-----	29	302	−49.7	-----	22	306	−45.9	-----	13	292	−54.1	-----
10,000	29	269	−49.9	-----	27	259	−54.6	-----	19	263	−51.1	-----	11	250	−56.5	-----
11,000	28	230	−56.0	-----	27	222	−56.8	-----	18	225	−55.7	-----	8	214	−55.5	-----
12,000	28	197	−59.8	-----	26	189	−56.8	-----	17	192	−59.7	-----	7	184	−54.8	-----
13,000	27	167	−60.8	-----	22	161	−56.6	-----	16	163	−61.7	-----	6	158	−54.8	-----
14,000	26	143	−61.6	-----	21	138	−57.2	-----	15	139	−62.5	-----	5	136	−55.1	-----
15,000	26	121	−62.7	-----	20	117	−58.3	-----	14	118	−64.1	-----	-----	-----	-----	-----
16,000	26	103	−63.2	-----	14	100	−59.7	-----	13	100	−64.2	-----	-----	-----	-----	-----
17,000	20	88	−63.2	-----	10	84	−59.6	-----	9	85	−64.1	-----	-----	-----	-----	-----
18,000	10	74	−62.0	-----	7	71	−59.4	-----	6	72	−64.3	-----	-----	-----	-----	-----
19,000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Altitude (meters) m. s. l.	Ketchikan, Alaska (26 m.)				Lakehurst, N. J.[1] (39 m.)				Medford, Oreg. (401 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	1,012	4.1	80	30	1,015	4.6	83	30	973	5.5	88
500	28	954	1.7	84	30	959	4.0	75	30	961	5.4	87
1,000	28	897	−1.1	84	30	902	2.3	73	30	904	5.2	76
1,500	28	842	−3.5	83	30	848	1.0	69	30	850	3.9	71
2,000	28	790	−5.9	80	30	796	−0.5	63	30	799	1.4	65
2,500	27	741	−8.8	77	30	748	−2.1	59	30	751	−1.0	61
3,000	27	694	−11.8	74	30	702	−4.2	59	30	705	−3.5	58
4,000	26	608	−18.3	70	30	617	−9.3	59	30	620	−9.2	53
5,000	26	532	−25.2	66	30	541	−15.2	58	30	545	−15.1	49
6,000	24	462	−32.0	64	29	474	−21.8	55	29	476	−21.8	46
7,000	24	400	−38.8	62	29	412	−28.5	57	28	415	−28.9	46
8,000	23	345	−45.3	-----	28	358	−35.3	50	28	360	−36.2	44
9,000	20	296	−50.9	-----	27	309	−41.9	-----	27	311	−43.7	-----
10,000	19	254	−53.1	-----	27	266	−48.2	-----	27	267	−51.1	-----
11,000	19	218	−53.7	-----	27	229	−53.6	-----	26	229	−57.1	-----
12,000	19	186	−53.3	-----	27	196	−57.6	-----	25	195	−60.7	-----
13,000	16	160	−52.7	-----	26	167	−60.4	-----	23	166	−62.5	-----
14,000	14	136	−52.5	-----	26	142	−62.1	-----	22	141	−64.1	-----
15,000	12	117	−52.8	-----	20	121	−63.8	-----	21	119	−64.9	-----
16,000	9	101	−52.8	-----	18	103	−64.8	-----	21	101	−64.1	-----
17,000	7	86	−53.3	-----	10	87	−64.4	-----	19	86	−63.7	-----
18,000	-----	-----	-----	-----	-----	-----	-----	-----	18	73	−63.7	-----
19,000	-----	-----	-----	-----	-----	-----	-----	-----	11	62	−63.2	-----

[1] U. S. Navy.

[2] Airplane observations.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during November 1940*—Continued

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Miami, Fla. (4 m.)				Nashville, Tenn. (180 m.)				Nome, Alaska (14 m.)				Norfolk, Va.[1 2] (10 m.)				Oakland, Calif. (2 m.)				Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	1,019	19.8	82	28	1,001	6.1	76	28	1,007	−3.8	83	23	1,024	8.4	77	29	1,019	10.5	76	29	975	5.4	79	30	965	0.6	81
500	30	962	18.8	78	28	963	6.6	74	28	947	−5.4	85	23	964	8.4	63	29	960	12.1	64	29	962	6.1	77	30	960	.7	77
1,000	30	908	15.9	79	28	906	5.1	70	28	889	−6.8	84	23	908	5.9	58	29	905	10.4	57	29	905	6.7	70	30	903	.4	72
1,500	30	856	13.0	78	28	852	3.7	64	28	833	−9.3	81	23	853	3.6	52	29	852	8.3	53	29	852	6.2	62	30	848	.7	65
2,000	30	806	11.5	66	28	801	2.2	59	28	781	−11.3	73	23	802	2.6	42	29	802	6.4	47	29	801	4.6	55	30	796	−.5	58
2,500	30	759	10.5	48	28	752	.4	53	28	731	−13.8	68	23	753	.2	40	29	754	4.2	40	29	753	2.6	52	30	748	−2.6	55
3,000	30	714	8.9	36	28	707	−1.4	49	28	684	−16.6	64	23	708	−2.1	34	29	709	1.4	35	29	708	.1	50	30	702	−4.8	53
4,000	29	633	4.0	28	27	623	−5.7	47	28	608	−22.6	62	23	624	−6.7	26	29	625	−4.5	32	29	624	−5.4	46	30	617	−11.0	49
5,000	28	559	−1.9	24	27	548	−11.3	41	28	521	−29.1	61	20	548	−12.3	24	29	550	−11.3	33	29	549	−11.7	43	30	542	−16.7	48
6,000	28	492	−8.1	22	25	480	−17.8	41	27	452	−36.0	58					29	482	−18.4	34	28	481	−18.1	39	30	473	−23.3	48
7,000	28	432	−14.5	24	25	420	−24.4	41	27	391	−42.8	58					29	421	−25.9	35	27	420	−25.4	39	29	412	−30.5	46
8,000	28	378	−22.0	24	25	365	−31.5	41	26	336	−48.9						29	365	−32 8	35	27	365	−32.7	36	29	357	−37.7	45
9,000	28	329	−29.6	23	24	316	−38.6	40	26	288	−53.0						29	316	−40.7		27	316	−40.4		28	308	−44.6	
10,000	28	286	−37.8	19	23	273	−45.7		26	247	−54.4						29	273	−48.9		27	273	−47.7		28	265	−50.5	
11,000	27	246	−46.1		23	234	−52.4		26	211	−53.7						27	234	−56.2		25	234	−53.5		28	227	−55.2	
12,000	26	212	−54.2		23	200	−57.9		26	181	−53.2						25	199	−60.6		21	200	−58.4		28	194	−57.3	
13,000	26	181	−61.8		22	171	−62.4		23	155	−51.9						24	169	−62.8		19	170	−62.9		26	165	−58.7	
14,000	26	153	−68.4		21	145	−65.8		22	133	−50.6						23	144	−63.0		17	145	−65.5		23	141	−60.2	
15,000	26	129	−73.1		20	122	−67.2		18	114	−50.5						23	122	−63.4		15	123	−67.8		21	119	−62.1	
16,000	26	109	−77.0		20	104	−68.2		14	97	−50.3						22	104	−65.3		13	104	−69.5		20	102	−62.7	
17,000	25	91	−78.6		18	87	−68.6		12	83	−50.6						19	88	−64.9		12	88	−70.2		17	86	−62.9	
18,000	21	77	−76.4		16	74	−67.8		7	72	−51.1						15	75	−63.8		10	75	−69.2		13	73	−62.3	
19,000	18	64	−71.9		11	62	−66.0										8	64	−63.8		5	63	−67.2					
20,000	12	55	−67.8		5	52	−64.7																					
21,000	8	46	−64.2																									

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Pearl Harbor, T. H.[1 2] (6 m.)				Pensacola, Fla.[1 3] (24 m.)				Phoenix, Ariz. (339 m.)				Portland, Maine (9 m.)				San Diego, Calif.[1] (19 m.)				Sault Ste. Marie, Mich. (221 m.)				Seattle, Wash.[1] (27 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	29	1,014	22.1	86	27	1,021	12.3	80	30	977	11.1	63	28	1,014	1.2	86	30	1,014	14.9	75	30	990	−1.7	86	26	1,017	5.9	85
500	29	958	21.9	77	27	964	12.6	70	30	959	15.1	56	28	956	1.4	83	30	958	15.1	46	30	956	−3.1	89	26	959	4.8	78
1,000	29	904	19.2	78	27	908	11.4	58	30	903	14.2	47	28	898	−.5	82	30	902	13.1	37	30	897	−5.6	92	26	903	2.8	71
1,500	29	853	16.5	75	27	856	9.7	54	30	851	11.1	45	28	843	−1.6	79	30	851	10.7	32	30	841	−6.9	88	26	848	.4	68
2,000	29	804	14.5	62	27	805	7.8	53	30	801	8.0	45	28	792	−3.6	78	30	801	8.6	27	30	789	−8.7	85	26	797	−1.8	64
2,500	29	758	13.2	45	26	757	6.2	49	30	754	5.4	45	28	743	−5.4	75	30	754	6.4	23	30	739	−10.3	79	26	747	−4.7	58
3,000	29	714	11.7	30	26	712	3.9	46	30	709	2.6	44	28	697	−7.2	73	30	708	3.6	20	30	692	−11.8	74	26	701	−7.5	54
4,000	29	633	7.0	22	21	629	−1.7	48	28	626	−3.1	40	28	613	−12.2	66	30	625	−2.5	22	30	607	−16.5	69	26	615	−14.0	59
5,000	5	560	1.2	16	15	555	−7.4	46	28	551	−9.9	37	27	537	−17.4	64	30	550	−9.1	31	30	531	−22.4	66	25	538	−20.2	59
6,000					14	488	−13.7	48	27	483	−16.9	36	26	469	−23.6	62	30	483	−15.7	40	30	463	−29.3	65	25	470	−27.3	56
7,000					14	426	−20.7	55	27	422	−24.1	35	26	408	−30.6	63	29	422	−23.5	48	30	401	−36.1	62	25	409	−33.6	57
8,000					11	373	−27.9	58	26	367	−31.1	35	26	354	−37.6	61	26	367	−31.2	48	30	347	−43.1		24	353	−40.6	60
9,000					9	323	−35.2		25	318	−38.4	35	26	306	−44.4		23	318	−38.5		29	298	−49.1		24	305	−47.1	
10,000					8	280	−42.6		21	275	−45.9		26	263	−49.5		20	274	−46.0		28	256	−53.6		22	262	−52.5	
11,000					8	242	−49.8		21	236	−52.5		26	226	−53.3		18	236	−53.2		27	219	−56.1		21	225	−56.5	
12,000									18	202	−58.0		25	193	−55.7		16	201	−58.8		25	187	−56.3		21	192	−58.2	
13,000									18	171	−61.6		25	165	−56.9		12	170	−61.9		23	159	−56.8		21	164	−58.4	
14,000									15	145	−65.2		25	141	−57.5		11	146	−64.4		22	136	−58.4		19	140	−58.8	
15,000									14	123	−67.4		23	120	−58.3		7	123	−67.3		20	116	−60.0		18	119	−59.5	
16,000									13	104	−69.4		21	103	−59.6		6	104	−67.9		18	99	−60.8		13	101	−59.6	
17,000									12	88	−68.5		15	88	−59.8						15	84	−61.5		9	86	−59.2	
18,000									10	75	−67.0		14	75	−60.2						9	72	−62.1		7	73	−60.2	
19,000									5	63	−64.2		7	64	−60.5						6	61	−62.3					

[1] U. S. Navy. [2] Airplane observations. [3] Radiosonde and airplane observations.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during November 1940*—Continued

Altitude (meters) m. s. l.	Washington, D. C.[1] (7 m.) Number of observations	Pressure	Temperature	Relative humidity	Altitude (meters) m. s. l.	Washington, D. C.[1] (7 m.) Number of observations	Pressure	Temperature	Relative humidity	Altitude (meters) m. s. l.	Washington, D. C.[1] (7 m.) Number of observations	Pressure	Temperature	Relative humidity
Surface	29	1,021	6.1	79	3,000	27	704	−3.3	55	8,000	10	361	−33.7	-----
5,00	29	961	5.4	73	4,000	27	619	−8.4	52	9,000	10	312	−40.5	-----
1,000	29	904	3.9	71	5,000	27	544	−13.8	53	10,000	6	269	−47.0	-----
1,500	29	850	2.5	69	6,000	27	476	−20.3	56	11,000	5	231	−52.7	-----
2,000	29	799	0.4	66	7,000	26	415	−27.2	61	12,000	5	198	−57.3	-----
2,500	29	750	−1.2	61										

LATE REPORT

Altitude (meters) M. S. L.	Juneau, Alaska (49 m.) Number of observations	Pressure	Temperature	Relative humidity	Altitude (meters) M. S. L.	Juneau, Alaska (49 m.) Number of observations	Pressure	Temperature	Relative humidity	Altitude (meters) M. S. L.	Juneau, Alaska (49 m.) Number of observations	Pressure	Temperature	Relative humidity
Surface	25	999	7.3	85	4,000	15	605	−15.7	71	11,000	7	216	−57.7	-----
500	25	946	5.5	80	5,000	13	529	−22.1	72	12,000	6	184	−56.4	-----
1,000	25	889	1.9	84	6,000	12	461	−29.1	68	13,000	6	157	−54.1	-----
1,500	24	835	−1.3	84	7,000	9	400	−36.7	-----	14,000	6	134	−53.6	-----
2,000	22	784	−4.2	85	8,000	8	344	−44.3	-----	15,000	6	114	−53.7	-----
2,500	21	736	−6.8	82	9,000	7	295	−50.9	-----	16,000	5	97	−55.0	-----
3,000	19	690	−9.6	77	10,000	7	253	−55.0	-----					

NOTE.—All observations taken at 12:30 a. m. 75th meridian time, except at Washington, D. C., and Lakehurst, N. J., where they are taken near 5 a. m., E. S. T., at Norfolk, Va., where they are taken at about 6 a. m., and at Pearl Harbor, T. H., shortly after sunrise.

None of the means included in this table are based on less than 15 surface or 5 standard level observations.

Number of observations refers to pressure only, as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40° C.

[1] U. S. Navy.

TABLE 2.—*Free-air resultant winds based on pilot balloon observations made near 5 p. m. (75th meridian time) during November 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.) Observations	Direction	Velocity	Albuquerque, N. Mex. (1,630 m.) Observations	Direction	Velocity	Atlanta, Ga. (299 m.) Observations	Direction	Velocity	Billings, Mont. (1,095 m.) Observations	Direction	Velocity	Bismarck, N. Dak. (512 m.) Observations	Direction	Velocity	Boise, Idaho (870 m.) Observations	Direction	Velocity
Surface	26	203	2.3	29	246	1.0	24	303	1.6	28	254	2.7	30	316	3.0	28	212	0.4
500	---	----	----	---	----	----	24	296	2.0	---	----	----	---	----	----	---	----	----
1,000	26	210	3.2	---	----	----	24	303	2.2	---	----	----	29	312	5.2	28	143	0.5
1,500	25	234	4.2	---	----	----	23	288	3.0	28	263	5.1	24	305	6.5	28	243	1.2
2,000	24	251	6.2	29	186	1.2	23	277	5.6	27	278	6.6	19	306	8.6	24	249	3.9
2,500	23	258	7.8	29	264	4.3	22	287	7.9	25	283	9.0	19	298	10.6	20	270	4.4
3,000	23	263	9.0	29	273	7.2	18	290	9.1	24	289	9.2	19	298	11.8	16	280	4.1
4,000	22	267	11.2	24	281	12.2	17	273	13.2	22	294	12.6	15	294	15.3	14	291	6.6
5,000	21	269	13.7	22	281	16.1	17	270	17.5	18	301	15.0	13	296	17.1	12	320	8.1
6,000	18	273	15.6	21	281	19.0	15	272	17.9	15	313	16.7	12	292	19.0	10	326	9.4
8,000	14	270	22.7	18	276	18.5	12	287	23.3	---	----	----	---	----	----	---	----	----
10,000	---	----	----	10	278	19.9	11	292	34.0	---	----	----	---	----	----	---	----	----

Altitude (meters) m. s. l.	Brownsville, Tex. (7 m.) Observations	Direction	Velocity	Buffalo, N. Y. (220 m.) Observations	Direction	Velocity	Burlington, Vt. (132 m.) Observations	Direction	Velocity	Charleston, S. C. (18 m.) Observations	Direction	Velocity	Chicago, Ill. (192 m.) Observations	Direction	Velocity	Cincinnati, Ohio (157 m.) Observations	Direction	Velocity	Denver, Colo. (1,627 m.) Observations	Direction	Velocity
Surface	25	120	2.7	28	260	4.8	29	218	2.0	27	286	0.5	25	264	2.9	26	260	2.8	30	27	1.5
500	25	132	3.1	28	257	7.5	29	225	5.2	27	280	1.2	25	248	5.1	26	259	4.6	---	----	----
1,000	25	168	2.3	23	250	9.5	27	252	6.5	26	266	2.8	21	263	6.8	24	252	6.6	---	----	----
1,500	24	214	2.9	16	238	11.0	16	264	7.9	25	262	3.4	20	273	8.8	21	263	8.7	---	----	----
2,000	20	223	4.0	11	265	14.1	12	264	9.8	24	270	4.9	19	269	9.9	17	267	9.8	30	9	1.2
2,500	18	221	4.7	---	----	----	---	----	----	24	274	6.3	19	275	11.4	15	275	11.4	29	284	2.0
3,000	15	233	6.3	---	----	----	---	----	----	22	276	9.2	19	278	13.1	15	278	14.0	29	281	4.0
4,000	14	257	7.2	---	----	----	---	----	----	19	263	12.6	16	283	16.7	12	274	16.3	26	284	8.7
5,000	13	264	7.8	---	----	----	---	----	----	17	258	14.6	15	292	21.2	---	----	----	23	276	14.3
6,000	11	269	10.5	---	----	----	---	----	----	12	279	16.6	13	291	25.8	---	----	----	20	281	18.8
8,000	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	16	274	22.3
10,000	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	---	----	----	13	277	27.8

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (75th meridian time) during November 1940. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second*—Continued

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)			Ely, Nev. (1,910 m.)			Grand Junction, Colo. (1,413 m.)			Greensboro, N. C. (271 m.)			Havre, Mont. (766 m.)			Jacksonville, Fla. (14 m.)			Las Vegas, Nev. (570 m.)			Little Rock, Ark. (79 m.)			Medford, Oreg. (410 m.)			Miami, Fla. (10 m.)			Minneapolis, Minn. (261 m.)			Mobile, Ala. (10 m.)			Nashville, Tenn. (194 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	29	260	0.8	28	336	1.8	28	296	1.1	25	254	1.8	23	250	1.9	28	59	2.4	30	71	2.0	23	49	0.1	26	337	0.7	30	72	3.8	26	262	2.1	30	85	0.5	26	271	1.7
500										25	253	3.1				28	87	2.5				23	259	0.8	26	344	0.8	30	67	5.8	26	272	2.6	30	104	1.6	26	259	2.6
1,000										24	257	4.9	23	255	5.0	28	98	0.8	30	44	1.5	23	264	2.8	26	179	1.0	30	65	5.2	20	271	4.9	30	24	1.3	24	246	3.4
1,500	29	243	1.3				28	298	1.5	24	267	6.8	23	277	9.4	28	258	1.2	30	5	1.0	21	273	4.4	23	216	2.9	27	73	3.0	18	284	7.4	27	317	1.6	22	247	4.4
2,000	29	245	2.8	28	326	2.0	28	292	1.6	23	283	9.3	20	281	11.0	27	268	2.2	30	298	2.5	21	275	6.4	21	251	4.1	25	59	1.7	15	285	9.6	26	287	3.7	21	266	7.0
2,500	28	258	4.2	28	300	2.2	28	270	2.2	22	277	10.6	19	283	11.0	25	280	4.6	30	311	3.3	20	277	9.3	17	256	3.3	25	55	0.9	14	294	11.0	26	272	6.0	20	270	8.7
3,000	28	265	5.7	28	294	3.2	26	249	3.6	19	283	12.6	18	285	11.0	24	273	6.0	29	299	4.5	18	283	12.1	13	265	5.0	20	39	1.4	14	294	12.7	24	263	8.4	18	279	10.8
4,000	26	267	8.3	27	303	7.2	21	280	7.8	17	291	15.1	16	294	13.6	23	265	8.6	27	293	6.6	16	283	15.2	11	271	4.7	19	301	0.9	10	315	14.1	21	258	10.6	16	271	16.1
5,000	21	275	10.3	22	306	11.0	17	298	12.7	15	285	17.6	13	298	14.6	24	269	11.5	27	285	8.6	10	283	16.8				19	276	3.5				20	262	13.0	12	267	21.9
6,000	18	266	12.1	22	308	14.9	12	305	11.2	14	279	19.8				22	268	15.3	27	282	10.9							17	273	4.1				13	270	11.7	10	258	26.2
8,000				16	315	18.8										18	282	18.1	23	289	15.6							16	296	8.3									
10,000				13	307	27.0										14	274	26.7	17	292	14.3							15	281	13.5									
12,000				12	308	29.6										11	278	31.9	15	283	18.5							12	300	18.4									
14,000																			11	259	19.4																		
16,000																			11	249	12.6																		

Altitude (meters) m. s. l.	New York, N. Y. (15 m.)			Oakland, Calif. (8 m.)			Oklahoma City, Okla. (402 m.)			Omaha, Nebr. (306 m.)			Phoenix, Ariz. (344 m.)			Rapid City, S. Dak. (982 m.)			St. Louis, Mo. (181 m.)			San Antonio, Tex. (183 m.)			San Diego, Calif. (15 m.)			Sault Ste. Marie, Mich. (230 m.)			Seattle, Wash. (14 m.)			Spokane, Wash. (603 m.)			Washington, D. C. (10 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	29	280	3.7	28	280	2.1	24	182	1.7	27	284	1.8	30	84	0.3	28	342	4.3	24	268	2.7	27	128	1.2	29	292	3.3	19	321	2.6	27	202	0.6	22	186	1.2	27	293	2.0
500	28	269	6.4	28	353	1.5	24	193	1.8	27	279	1.7	30	124	.2				24	255	4.9	27	112	1.6	29	302	2.3	19	302	2.7	27	184	1.9				27	267	4.1
1,000	26	277	9.1	28	343	2.0	24	210	3.2	26	280	3.6	30	72	.5	28	342	4.4	24	251	6.4	24	215	1.1	29	353	.9	16	300	4.8	23	200	3.6	22	199	2.3	26	260	7.2
1,500	21	283	9.4	27	334	2.8	24	261	5.6	20	270	7.3	30	177	.6	28	305	6.5	21	266	7.9	21	241	3.5	28	35	1.7	12	299	7.1	20	210	4.8	20	226	3.6	23	271	10.8
2,000	16	288	8.6	25	328	3.3	24	265	7.7	17	280	9.0	30	235	2.1	27	300	8.1	20	269	11.1	18	263	4.1	25	26	1.8				19	227	5.8	16	239	5.7	20	284	13.7
2,500				25	330	4.8	23	266	9.5	17	286	10.9	30	276	2.2	26	302	10.0	19	273	10.8	17	262	5.5	24	360	2.2				19	238	6.9	16	264	6.4	19	280	14.4
3,000				25	322	5.7	22	271	10.5	17	286	12.0	30	280	3.6	26	302	10.8	18	278	12.6	15	270	7.3	23	319	3.3				15	249	6.7	15	281	7.6	17	285	16.0
4,000				23	318	7.6	19	281	14.7	16	297	15.7	26	290	5.6	24	299	11.0	16	289	16.2	12	278	9.7	22	325	4.5				13	262	8.6	12	298	9.9	16	292	19.0
5,000				21	312	7.9	18	281	17.1	14	290	20.1	26	285	7.0	24	292	15.8	15	286	18.3				21	316	4.6										15	284	23.0
6,000				19	317	12.6	17	283	21.2	14	289	23.6	24	287	9.6	20	294	18.9	12	290	20.4				12	315	5.3										12	291	26.2
8,000				11	299	13.7							18	276	15.5	15	290	23.1	10	300	27.1																		
10,000													12	267	15.7	13	290	26.2																					
12,000																11	287	24.4																					

TABLE 3.—*Maximum free-air wind velocities (m. p. s.), for different sections of the United States, based on pilot-balloon observations during November 1940*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	47.0	WSW	2,100	12	Buffalo, N. Y.	62.4	WNW	3,610	22	Binghamton, N. Y.	60.0	WNW	8,030	21	Caribou, Maine.
East-Central [2]	36.6	NW	2,341	28	Greensboro, N. C.	46.4	WSW	4,141	29	Greensboro, N. C.	97.8	W	12,014	28	Greensboro, NC.
Southeast [3]	34.2	WSW	2,500	11	Birmingham, Ala.	55.6	SW	5,000	14	Atlanta, Ga.	70.5	W	12,790	28	Jacksonville, Fla.
North-Central [4]	41.0	WSW	2,000	12	Detroit, Mich.	45.5	NW	5,000	16	Fargo, N. Dak.	78.0	NW	9,712	28	Rapid City, N. Dak.
Central [5]	46.4	W	2,260	12	Moline, Ill.	45.0	WNW	4,600	2	Chicago, Ill.	74.0	W	11,580	27	Wichita, Kans.
South-Central [6]	36.0	WSW	2,270	10	Amarillo, Tex.	49.4	WNW	4,250	11	Houston, Tex.	75.0	SW	14,510	21	Abilene, Tex.
Northwest [7]	31.8	WNW	1,510	28	Billings, Mont.	44.0 44.0	WNW W	4,310 4,510	28 29	Butte, Mont. Missoula, Mont.	62.4	NNW	9,058	12	Spokane, Wash.
West-Central [8]	43.8	S	2,080	3	Modena, Utah	47.8	NW	3,880	28	Denver, Colo.	98.4	N	11,120	22	Winnemucca, Nev.
Southwest [9]	35.2	WSW	2,458	10	Roswell, N. Mex.	49.9	WNW	5,000	11	Albuquerque, N. Mex.	71.5	WNW	13,340	10	Las Vegas, Nev.

[1] Maine, Vermont New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, Southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except extreme west Texas), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during November 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*

Stations	Anchorage, Alaska			Bismarck, N. Dak.			Brownsville, Tex.			Charleston, S. C.			Denver, Colo.			El Paso, Tex.		
Potential temperatures, °A.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299	10	6.6	-43.9	2	6.8	-46.0	------	------	------	------	------	------	------	------	------	------	------	------
300-309	10	8.2	-51.7	14	8.0	-48.6	------	------	------	------	------	------	6	7.6	-42.7	------	------	------
310-319	19	9.2	-55.3	15	9.4	-54.0	------	------	------	2	9.6	-42.5	16	8.5	-43.6	3	7.6	-34.3
320-329	12	10.3	-59.4	25	10.5	-57.4	2	8.6	-32.0	12	8.8	-37.7	26	10.4	-55.2	10	9.6	-46.5
330-339	1	11.0	-57.0	4	11.3	-60.5	6	11.0	-49.8	11	10.8	-50.0	12	11.5	-58.8	21	11.6	-57.9
340-349	2	11.4	-55.0	3	12.2	-61.3	11	13.1	-64.6	18	12.6	-60.6	6	12.4	-60.7	8	12.7	-62.9
350-359	1	11.9	-54.0	------	------	------	21	14.3	-70.1	13	13.7	-66.2	2	14.0	-66.5	9	13.8	-67.2
360-369	1	11.7	-48.0	3	13.6	-63.0	11	15.4	-75.7	4	14.9	-71.2	5	13.8	-63.6	2	14.8	-72.5
370-379	------	------	------	2	14.5	-63.0	8	16.1	-77.0	10	15.5	-71.5	4	14.5	-64.2	5	15.1	-69.8
380-389	1	13.8	-55.0	4	14.4	-59.8	4	16.6	-76.2	6	16.0	-72.0	2	15.3	-68.0	8	15.8	-70.5
390-399	2	14.4	-55.0	2	14.8	-59.0	4	17.1	-76.8	5	16.6	-73.2	6	15.6	-64.7	4	16.5	-72.2
400-409	------	------	------	------	16.6	-69.0	1	17.3	-75.0	5	17.0	-71.6	2	15.6	-62.0	2	16.4	-68.5
Weighted means	------	9.3	-53.5	------	10.5	-55.8	------	14.4	-68.9	------	13.1	-60.4	------	11.2	-55.3	------	12.8	-60.8
Mean potential temperature, °A. (weighted)	318.0			328.3			358.9			354.4			337.7			350.1		
Number days with observations	25			29			24			25			27			21		

Stations	Ely, Nev.			Great Falls, Mont.			Joliet, Ill.			Ketchikan, Alaska			Lakehurst, N. J.			Medford, Oreg.			Miami, Fla.		
Potential temperatures, °A.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299	------	------	------	9	7.1	-48.9	3	6.2	-41.7	8	6.8	-46.4	1	5.5	-29.0	2	7.2	-44.5	------	------	------
300-309	6	7.1	-40.2	15	7.6	-43.8	3	7.5	-47.0	14	8.1	-50.4	3	7.4	-40.7	3	7.1	-37.3	------	------	------
310-319	12	8.5	-43.1	17	9.3	-52.0	7	8.9	-48.4	16	9.5	-55.8	6	8.9	-46.8	6	8.7	-45.0	------	------	------
320-329	20	10.7	-57.1	18	10.7	-58.5	10	10.1	-53.5	7	10.3	-56.6	14	10.5	-49.1	27	10.5	-55.3	1	9.6	-41.0
330-339	22	18.2	-62.1	4	11.5	-61.0	9	11.8	-62.0	4	10.9	-55.8	17	11.5	-59.2	10	12.2	-66.3	11	10.4	-42.5
340-349	6	12.7	-64.5	1	11.5	-56.0	3	12.7	-64.7	1	11.7	-57.0	7	12.2	-61.3	3	12.5	-61.7	28	12.6	-59.2
350-359	3	13.2	-62.7	------	------	------	1	12.5	-58.0	1	11.9	-54.0	2	13.2	-63.0	5	13.3	-65.2	13	14.2	-69.2
360-369	1	12.9	-55.0	1	12.8	-55.0	2	13.0	-58.5	2	12.8	-55.5	2	13.8	-62.5	6	14.5	-69.2	8	15.2	-73.6
370-379	4	14.6	-64.2	1	15.9	-76.0	4	14.7	-65.5	------	------	------	3	14.7	-66.7	2	14.8	-66.5	10	16.2	-78.5
380-389	4	15.4	-67.0	2	15.6	-64.0	1	13.5	-53.0	1	14.3	-57.0	1	15.6	-67.0	5	14.9	-63.6	9	16.7	-76.8
390-399	7	16.1	-66.7	------	------	------	2	15.8	-65.5	1	14.8	-59.0	4	15.8	-64.8	1	15.8	-64.0	4	17.6	-80.2
400-409	4	16.0	-62.8	3	16.0	-64.3	2	15.7	-63.0	1	14.9	-56.0	1	14.8	-55.0	------	------	------	------	------	------
Weighted means	------	11.7	-57.8	------	9.7	-53.3	------	11.1	-56.1	------	9.4	-53.2	------	11.5	-55.5	------	11.5	-58.1	------	13.9	-64.9
Mean potential temperature °A. (weighted)	341.0			321.5			336.6			319.5			338.7			336.7			356.2		
Number days with observations	28			28			18			21			27			24			26		

Stations	Nashville, Tenn.			Nome, Alaska			Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.			Phoenix, Ariz.			Portland, Me.		
Potential temperatures, °A.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m.s.l.	Mean temperature °C.
290-299	------	------	------	11	6.9	-48.3	------	------	------	------	------	------	2	6.8	-47.5	------	------	------	------	------	------
300-309	------	------	------	18	8.0	-49.7	2	6.8	-35.5	1	7.5	-45.0	6	7.7	-46.5	1	6.5	-30.0	------	------	------
310-319	3	8.5	-43.7	11	9.5	-56.5	8	8.2	-40.0	4	8.8	-48.5	17	8.3	-42.1	3	7.3	-34.3	20	8.5	-47.1
320-329	12	9.3	-42.4	10	10.4	-59.9	20	10.6	-56.2	14	10.0	-48.9	23	10.4	-54.9	10	10.3	-51.5	17	10.3	-54.8
330-339	13	11.3	-56.0	------	------	------	14	12.0	-63.1	11	11.5	-57.9	11	11.4	-59.5	13	11.3	-56.2	11	11.3	-58.1
340-349	12	12.7	-62.7	1	10.6	-52.0	10	12.7	-64.4	6	12.7	-63.7	8	12.3	-60.9	6	12.6	-63.0	4	12.5	-63.5
350-359	8	13.6	-65.5	------	------	------	2	13.0	-60.0	7	13.2	-63.3	1	12.3	-57.0	7	13.7	-65.3	7	12.8	-58.6
360-369	7	14.3	-67.7	2	12.6	-54.5	1	14.4	-68.0	3	14.8	-71.0	6	13.6	-62.0	2	14.8	-70.5	------	------	------
370-379	5	15.0	-67.8	------	------	------	5	14.2	-62.2	4	15.0	-68.5	3	14.5	-64.3	3	15.3	-71.3	1	13.1	-56.0
380-389	4	15.5	-67.5	------	------	------	3	15.8	-70.0	4	15.3	-67.5	6	15.0	-63.7	4	15.8	-70.0	5	14.2	-58.0
390-399	4	16.4	-71.2	1	13.9	-50.0	3	15.7	-65.0	4	16.2	-69.2	4	15.6	-66.2	2	16.1	-68.0	2	15.2	-60.5
400-409	4	16.8	-69.5	------	------	------	4	16.4	-65.8	3	17.2	-73.0	4	16.3	-65.0	2	16.8	-60.0	4	15.8	-61.8
Weighted means	------	12.7	-59.6	------	8.9	-52.9	------	11.9	-58.5	------	12.4	-59.7	------	11.2	-55.2	------	12.3	-58.9	------	11.1	-54.8
Mean potential temperature °A. (weighted)	351.2			311.7			342.0			348.1			338.7			346.1			338.5		
Number days with observations	22			26			24			19			27			18			25		

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during November 1940, classified according to the potential temperatures (10° intervals between 290° and 409° A.) with which they are identified (based on radiosonde observations)*—Con.

Stations	Sault Ste. Marie, Mich.			Seattle, Wash.		
Potential temperatures, °A.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290-299	4	6.6	−44.2	1	7.8	−54.0
300-309	14	7.6	−45.1	6	8.2	−51.3
310-319	23	9.0	−51.3	4	9.4	−54.8
320-329	15	10.5	−58.3	16	10.3	−56.2
330-339	7	10.5	−53.6	5	12.0	−63.0
340-349	2	11.4	−57.0			
350-359	1	11.7	−50.0			
360-369	2	13.0	−61.5	2	14.4	−68.0
370-379	2	13.4	−58.5	1	14.4	−66.0
380-389	5	14.5	−60.2	1	13.8	−53.0
390-399	4	14.6	−58.2			
400-409	3	15.3	−59.0	1	16.0	−62.0
Weighted means		10.2	−53.1		10.6	−57.1
Mean potential temperature °A., (weighted)		330.2			327.8	
Number days with observations		27			22	

WEATHER ON THE NORTH ATLANTIC OCEAN

By H. C. HUNTER

Atmospheric pressure.—The pressure during November 1940 averaged higher than normal over nearly all portions of the North Atlantic well covered by available reports. This is in contrast to the conditions during the preceding 2 months, when pressure below normal was the rule. The November departures were greatest over the southeastern region, Lisbon, Portugal, averaging 5.3 millibars (0.16 inch) above the normal for the month.

The extremes of pressure in the vessel reports available were 1,039.2 and 999.0 millibars (30.69 and 29.50 inches). The higher reading was noted on United States Coast Guard cutter *Mendota*, near 39½° N., 59° W., during the forenoon of the 12th. The low mark was recorded on the Honduran steamship *Iriona*, during the forenoon of the 27th, when about 130 miles to south-southwestward of Nantucket. Table 1 shows that within 48 hours of the *Iriona's* observation, readings somewhat lower were noted at the land stations at Nantucket and Halifax, and a reading decidedly lower at Belle Isle, Newfoundland.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, November 1940*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Lisbon, Portugal	1,022.6	+5.3	1,032	3	1,006	16
Horta, Azores	1,024.3	+4.0	1,032	22	1,014	20
Belle Isle, Newfoundland	1,008.3	+0.2	1,038	12	961	29
Halifax, Nova Scotia	1,016.8	+2.6	1,038	11	994	28
Nantucket	1,018.6	+1.0	1,037	19	994	27
Hatteras	1,021.3	+1.7	1,036	19	1,006	27
Turks Island	1,015.0	−0.6	1,018	[1] 10	1,008	6
Key West	1,018.3	+1.7	1,024	17	1,013	7
New Orleans	1,021.3	+2.0	1,034	15	1,006	25

[1] Also several later dates.

NOTE.—All data based on available observations, departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—For the time of year the weather was comparatively quiet over those North Atlantic regions that are well covered by reports at hand. The period from the 15th to 24th was particularly free from strong winds.

A LOW system extending far in a north-south direction moved eastward off the North American coast on the 2d and 3d, and on the morning of the 4th was located approximately along the 58th meridian. The sole North Atlantic whole-gale report of the month was connected with this storm; it was made by the Coast Guard cutter *Pontchartrain*.

During the final week of the month another cyclonic system greatly affected the weather on the ocean, and brought usually lower barometric readings than the system just mentioned, although no wind force exceeding 9 (strong gale) is noted among the available reports. This LOW system crossed the coast line on the 27th and 28th, and traveled toward the northeast till beyond the field of observation.

Fog.—Remarkably few reports of fog have been received. However, it is worth noting that the first advices of Gulf of Mexico fog since spring came to hand; two occurrences over the north-central portion during the latter part of November have been reported.

Over the main North Atlantic waters there was fog on three dates, all during the first half of the month, to southeastward of New Jersey and Delaware, that is, in the 5° square, 35° to 40° N., 70° to 75° W. This is about the normal November amount of fog in the area. In the region adjacent to Cape Cod and western Nova Scotia, where normally fog is encountered on 4 days in November, no reports whatever for the current November have arrived.

Three fog reports have come, in addition to the five dates previously noted. One occurrence was to southeastward of Nova Scotia on the 16th; the other two relate to fog on the 12th and 13th a short distance to southwestward of Portugal in the square, 35° to 40° N., 10° to 15° W.

OCEAN GALES AND STORMS, NOVEMBER 1940

Vessel	Voyage		Position at time of lowest barometer		Gale began November	Time of lowest barometer November	Gale ended November	Lowest barometer	Direction of wind when gale bagan	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To-	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Sebago, U. S. C. G.	On station No. 2.		40 18 N.	43 30 W.	1	6p, 1	2	1,004.1	SSW	WNW, 7	NNW	SW, 9	W-NNW.
Tachira, Pan. S. S.	Barranquilla	New York	35 48 N.	74 00 W.	2	1p, 2	2	1,013.5		NW, 8		NW, 8	SSE-NW.
Pontchartrain, U. S. C. G.	On station No. 1.		38 24 N.	59 30 W.	3	2a, 4	5	1,012.2	SSE	WSW, 9	WNW	SSW, 10	WSW-NNW.
West Irmo, Am. S. S.	Freetown	Philadelphia	36 20 N.	69 53 W.	6	1p, 6	6	1,009.1	WSW	WNW, 4	WNW	WSW, 8	SW-WNW.
Tahoe, U. S. C. G.	New Bedford	Station No. 2	40 49 N.	46 02 W.	8	11a, 8	8	1,010.8	SSW	SSW, 7	SSE	S, 8	SSW-SSE.
Sebago, U. S. C. G.	Station No. 2	Norfolk	39 48 N.	54 00 W.	8	4p, 9	10	1,003.1	SSW	S, 5	N	SSW, 9	NNW-S-NE.
Excambion, Am. S. S.	Bermuda	Lisbon	34 42 N.	49 42 W.	12	2p, 12	13	1,020.0	NNE	NE, 8	E	NE, 9	NNE-ENE.
William Boyce Thompson, Am. S. S.	Tuxpam	Houston	22 18 N.	96.48 W.	13	6p, 13	14	1,018.3	NNW	N, 7	N	NNW, 8	
Labette, Am. S. S.	Norfolk	do	[1] 15 55 N.	86 38 W.	14	4a, 14	15	1,016.3	N	N,—	N	N, 8	
Mendota, U. S. C. G.	On station No. 1.		38 48 N.	59 00 W.	25	1p, 25	25	999.7		W, 7		NW, 8	WSW-NW.
Tahoe, U. S. C. G.	On station No. 2.		38 24 N.	45 48 W.	25	6a, 26	26	1,007.1	S	SW, 8	NW	SW, 8	S-NW.
New York, Am. S. S.	Port Arthur	Portland, Maine.	35 48 N.	73 48 W.	27	4p, 27	28	1,007.1	WNW	NW, 2	NW	WNW, 8	WNW-NW.
Mendota, U. S. C. G.	On station No. 1.		38 40 N.	58 35 W.	27	12m, 28	28	999.7	SSW	SSW, 7	NW	SW, 8	SSW-WNW.
Champlain, U. S. C. G.	New York	Station No. 2	39 30 N.	56 48 W.	27	2p, 28	28	999.3	SSE	SSW, 7	SW	SSE, 9	SSW-W.
Tahoe, U. S. C. G.	Station No. 2	New Bedford	38 54 N.	48 12 W.	28	3a, 29	29	1,008.5	SW	SW, 8	NW	SW, 8	SSW-NW.
NORTH PACIFIC OCEAN													
Wacosta, Am. S. S.	Honolulu	Balboa	15 18 N.	107 18 W.	1	10p, 1	2	1,004.7	NNE	NE, 10	SSE	NE, 10	NE-SSE.
Pan Kraft, Am. S. S.	Santo Nino, P. I.	Honolulu	15 25 N.	145 26 E.	2	2p, 3	4	998.0	NE	ENE, 9	SE	ENE, 9	
Collingsworth, Am. S. S.	Tacoma	Manila	42 12 N.	152 48 E.	3	6p, 3	4	1,014.9	WSW	WSW, 8	NW	WSW, 10	
Chickasaw City, Am. S. S.	Singapore	Honolulu	13 30 N.	144 00 E.	2	6p, 3	5	961.7	NNE	ENE, 12	SSW	ENE, 12	NE-SE.
Schoharie, Am. S. S.	Bintang, D. E. I.	do	11 57 N.	142 42 E.	3	10p, 3	4	991.2	N	SW, 8	SE	SSW, 10	W-SSW.
Denali, Am. S. S.	Ketchikan	Seattle	[1] 50 48 N.	127 12 W.	3	6p, 3	4	1,012.9	SE	SE, 6	E	E, 9	
Aurora, Am. S. S.	Vladivostok	Los Angeles	47 25 N.	152 00 W.	4	10p, 4	5	1,000.3	E	E, 8	NE	E, 8	E-NE.
District of Columbia, Am. S. S.	Seattle	San Francisco	40 26 N.	124 34 W.	4	12p, 4	5	1,010.2	S	S, 10	SSE	S, 10	S-SSE.
Lightship No. 92 (relief), U. S.	On station		48 33 N.	125 00 W.	4	2a, 5	5	[2] 1,000.3	E	SE, 7	SE	SE, 9	SE-SW.
Do	do		48 33 N.	125 00 W.	6	6a, 7	7	[2] 985.4	ENE	SE, 9	SW	SE, 9	ESE-SW.
Winkler, Pan. M. S.	Tokuyama	Los Angeles	42 54 N.	172 24 W.	7	12a, 7	8	1,000.0		WNW, 9		WNW, 9	
S. C. T. Dodd, Am. S. S.	San Francisco	Nagaeva	50 00 N.	163 54 W.	7	1a, 8	8	1,006.1	ESE	E, 8		ESE, 9	ESE-ENE.
Asuka Maru, Jap. M. S.	Yokohama	San Francisco	46 33 N.	152 37 W.	7	4a, 8	8	998.9	S	ESE, 8	ESE	ESE, 8	ESE-SSE.
Collingsworth, Am. S. S.	Tacoma	Manila	31 06 N.	134 42 E.	8	2p, 8	9	1,009.1	NNE	NNE, 8	N	NNE, 9	
Mariposa, Am. S. S.	Honolulu	Shanghai	29 36 N.	142 00 E.	7	10p, 8	9	1,001.7	S	SSE, 4		NNE, 9	
Deroche, Am. S. S.	Oleum, Calif.	Honolulu	30 30 N.	141 36 W.	11	3a, 11	11	1,005.4	SSE	SSE, 8	WSW	SSE, 8	SSE-WSW.
President Cleveland, Am. S. S.	San Francisco	do	30 21 N.	142 22 W.	10	4a, 11	11	1,004.4	S	S, 9	SW	S, 9	S-SW.
Mauna Ala, Am. S. S.	Seattle	do	39 00 N.	140 24 W.	10	2p, 11	11	1,000.7	SE	W, 2	WSW	SE, 8	SE-W-SSW.
Arctic, U. S. N.	San Francisco	do	31 24 N.	139 36 W.	11	5p, 11	11	1,008.5	S	WSW, 4	WSW	SSE, 9	SSE-WSW.
S. C. T. Dodd, Am. S. S.	do	Nagaeva	[1] 50 39 N.	174 25 E.	12	6p, 12	13	973.2	ESE	S, 3	NW	N, 10	ESE-S-E.
Otowasan Maru, Jap. M. S.	Uno	San Luis	40 36 N.	171 48 W.	13	1a, 13	13	1,006.6		W, 7		WNW, 8	W-WNW.
Denali, Am. S. S.	Seward	Icy Strait	59 10 N.	145 52 W.	13	10a, 13	13	988.5	ESE	SE, 8	SE	SE, 8	ESE-S.
Lightship No. 92 (relief), U. S.	On station		48 33 N.	125 00 W.	12	4p, 13	13	[2] 1,019.3	ENE	E, 7	E	ENE, 8	
Tuscaloosa City, Am. S. S.	Balboa	Los Angeles	13 48 N.	95 12 W.	14	4p, 14	16	1,008.1	NNW	N, 8	E	ENE, 9	
President Harrison, Am. S. S.	do	do	13 24 N.	94 48 W.	14	2a, 15	15	1,009.8	NNW	NNE, 9	ENE	NNE, 10	NNW-NE.
Braianta, Nor. M. S.	Yokohama	San Francisco	[1] 38 15 N.	175 15 W.	15	8p, 15	15	1,010.2		SSW, 8	SSW	SW, 9	SW-SSW-WNW.
S. C. T. Dodd, Am. S. S.	San Francisco	Nagaeva	51 06 N.	158 00 E.	15	11p, 15	15	1,004.7		NE, 8		E, 9	
Mauna Kea, Am. S. S.	Balboa	San Diego	15 18 N.	93 12 W.	16	6p, 16	17	1,011.2	NW	NW, 3	WSW	NNW, 10	NW-NNW.
Liberty, U. S. A. T.	Seward	San Francisco	[1] 55 39 N.	143 10 W.	17	8p, 17	18	998.0	SE	S, 8	SSW	S, 8	ESE-SSW.
Chirikof, U. S. A. T.	Seattle	Seward	59 18 N.	145 00 W.	17	2a, 18	18	991.9	E	S, 6	S	ENE, 9	SSE-SSW.
Hokkai Maru, Jap. M. S.	Yokohama	Los Angeles	44 36 N.	148 30 W.	22	8p, 22	23	993.2	W	SSW, 8	W	SW, 8	W-SSW-WSW.
Admiral Cole, Am. S. S.	Vladivostok	San Francisco	[1] 38 05 N.	170 41 W.	22	5a, 23	22	1,001.7	SE	SE, 2	SSE	SE, 8	SE-NW.
Chirikof, U. S. A. T.	Seward	do	52 18 N.	142 48 W.	22	3p, 23	23	986.8	ENE	N, 5	N	ENE, 10	None.
Lightship No. 92 (relief), U. S.	On station		48 33 N.	125 00 W.	22	8p, 23	24	[2] 1,006.4	ENE	NE, 8	SSE	SSE, 9	E-NE-SSE.
Huguenot, Am. S. S.	Portland, Oreg.	Los Angeles	42 36 N.	125 00 W.	23	10p, 23	24	1,017.3	S	S, 9	S	S, 10	None.
Admiral Cole, Am. S. S.	Vladivostok	San Francisco	[1] 37 08 N.	161 42 W.	24	4a, 25	25	999.3	S	SW, 4	S	S, 9	S-SW.
Huzisan Maru, Jap. M. S.	Yokohama	Los Angeles	43 00 N.	167 36 W.	25	1p, 25	25	982.4		N, 9		N, 9	
S. C. T. Dodd, Am. S. S.	Nagaeva	San Francisco	50 12 N.	159 24 E.	25	11p, 25	26	1,002.7	SE	SE, 8		SE, 8	SE-SW.
Crown City, Am. M. S.	Yokohama	Seattle	49 00 N.	177 48 E.	27	12p, 28	28	974.6		W, 2		SSE, 8	SW-W.
S. C. T. Dodd, Am. S. S.	Nagaeva	San Francisco	45 54 N.	177 48 E.	27	12a, 29	29	972.2	SE	WNW, 9	WNW	SW, 9	NW-WNW-NW.
Brunswick, Pan. M. S.	Yokohama	Los Angeles	35 25 N.	174 21 E.	29	4a, 29	20	1,009.1	W	W, 8	WNW	W, 9	W-WNW.

[1] Position approximate.
[2] Barometer uncorrected.

WEATHER ON THE NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—In extreme northern waters of the North Pacific, pressure conditions showed a remarkable change from those in the preceding month. The Aleutian LOW, which was centered as a deep depression over the Gulf of Alaska in October, retreated with much decrease in energy to the central and western part of the Bering Sea in November. At Kodiak and Juneau, where the average pressure had been 5 or 6 millibars (0.15 to 0.19 inch) below the normal in October, it had risen to 7 or 8 millibars (more than 0.20 inch) above the normal in November. High pressure for the month continued southward along the coast to the United States, and at Tatoosh Island it was 4 millibars (0.12 inch) above the November long-term average.

Along the belt of high pressure, which extended from California across the ocean to China, the barometer, as indicated by San Francisco, Midway Island, and Titijima, was close to its November normal; but at Honolulu the average pressure was 3 millibars, or nearly a tenth of an inch, below the normal. So great a departure in an average is rare at this island station.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, November 1940, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Barrow	1,014.8	−0.8	1,034	24, 25	985	20
Dutch Harbor	1,005.1	+3.1	1,026	21	967	13
St. Paul	1,002.6	+.6	1,024	22	974	19
Kodiak	1,008.3	+7.3	1,029	21	981	15
Juneau	1,015.6	+7.8	1,029	11	997	24
Tatoosh Island	1,019.0	+4.1	1,032	25	986	7
San Francisco	1,019.6	+.6	1,027	24	1,013	1
Mazatlan	1,012.0	−.2	1,014	16, 18, 23	1,009	6
Honolulu	1,013.5	−3.1	1,019	2	1,007	20
Midway Island	1,019.0	+.4	1,027	15	1,010	8
Guam	1,009.7	−1.5	1,014	10, 14	956	3
Manila	1,010.1	−.1	1,013	10, 11, 30	1,007	26
Hong Kong						
Naha	1,017.7	+2.5	1,024	10	1,013	7, 23, 24, 29
Titijima	1,016.2	+1.0	1,025	5	973	9
Petropavlovsk[1]	1,002.8	−2.3	1.022	12	980	21

[1] For 21 days.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observations.

Extratropical cyclones and gales.—A considerable amount of stormy weather occurred on the North Pacific this month, but, so far as ships' reports indicate, there was a conspicuous absence of gales of hurricane or near hurricane force due to cyclones of middle and higher latitudes. On 7 days of the month force-10 gales were reported near or well north of the 40th parallel. The high velocities on 3 of these days, the 4th, 5th, and 24th, occurred off the coast of northern California and Oregon. One of the gales occurred on the 3d, near 42° N., 153° E., in the extreme southern quadrant of a deep cyclone central in the western Bering Sea, and the remaining 3, on the 13th, 22d, and 23d, were encountered in much higher latitudes, near the Aleutians or on the lower Gulf of Alaska.

As the average position of the Aleutian LOW this month was in the Bering Sea, it may be inferred that the centers of a predominant number of the cyclonic disturbances moved in upper latitudes, with some storms entering the Bering Sea from Kamchatka, and others from southwest of the Aleutians. Four of the cyclones were reported as attended by gale winds along the western part of the northern trans-Pacific routes: one on the 3d, east of northern Japan; one over the Aleutians on the 13th; one near the northern Kuril Islands on the 15th; and the fourth from near southern Kamchatka on the 25th to the waters south of the western Aleutians on the 27th and 28th. In the storms of the 13th and the 25th to 28th, pressures fell to considerable depths. On the 13th, near 51° N., 175° E., the American steamer *S. C. T. Dodd* had a barometer of 973.2 millibars (28.74 inches), with a north gale of force 10. Dutch Harbor on this date had the lowest known barometer reading of the month in northern waters, 967 millibars (28.56 inches). On the 28th and 29th the *S. C. T. Dodd* reported westerly gales of force 9, with lowest barometer, 972.2 millibars (28.71 inches), near 46° N., 178° E., on the 29th.

Mention may be made of three cyclones of the extratropics that formed near midocean and pursued northerly courses. One appeared central on the 9th near 32° N., 155° W. By the 11th it had entered the region traversed by ships along the Hawaiian-California routes, and on that date several vessels within the area of 28° to 40° N., 138° to 145° W., encountered south to southeast gales of force 8 to 9, with moderately depressed barometers. On the 13th this cyclone amalgamated with another, eastbound, cyclone to the northward.

On November 20 a depression appeared to the westward of the principal group of the Hawaiian Islands. It moved rapidly north-northeastward, gaining in intensity, and was central near 45° N., 150° W., on the 22d. Near the center on that date one vessel reported a southwesterly gale of force 8, with barometer fallen to 993.2 millibars (29.33 inches). By the morning of the 23d the storm had advanced to a position west of the Queen Charlotte Islands, and on the following day had turned northwestward into the Gulf of Alaska. The cyclone was apparently at its stage of greatest severity during the night of the 22d–23d, when the U. S. A. T. *Chirikof*, southbound from Seward, ran into a northeasterly gale of force 10, lowest barometer 986.8 millibars (29.14 inches), near 52° N., 143° W.

On the 22d to 25th scattered gales of force 8 to 9 were reported within the area 37° to 43° N., 165° to 172° W., caused by a cyclone that seems to have formed in the vicinity and to have had a very slow northeastward movement before its disappearance on the 27th. On the 25th, with a north gale of force 9, near 43° N., 168° W., the lowest barometer observed was 982.4 millibars (29.01 inches), read on the Japanese M. S. *Huzisan Maru*.

In American coastal waters, from northern California to Vancouver Island, stormy weather occurred on several days, but more particularly, along the greater extent of the coast, on the 4th and 5th, with gales of force 10 reported off California and Oregon and of force 9 off northwestern Washington and Vancouver Island. Relief Lightship No. 92, at the entrance to the Strait of Juan de Fuca, experienced gales of force 8 to 10 on the 4th, 7th, 13th, and 23d, while on the 24th the lower Oregon coast was swept by a southerly gale of force 10.

Tropical cyclones.—Hereunder is a report by the Rev. Bernard F. Doucette, S. J., Weather Bureau, Manila, P. I., of a typhoon of the Far East from November 2 to 10, which was of serious consequences to the island of Guam, and of a depression later in the month. The American S. S. *Chickasaw City* passed through the Guam typhoon, battling winds of force 11 to 12 from about 8 a. m. of the 3d until about 6 a. m. of the 4th, lowest barometer 961.7 millibars, 28.40 inches, at 6 p. m. of the 3d.

In the American Tropics, the American S. S. *Wacosta* ran into a cyclone of considerable intensity on the 1st and 2d, while at some distance southwest of Manzanillo, Mexico. The vessel's highest wind velocity was of force 10 from the northeast, lowest barometer, 1,004.7 millibars (29.67 inches), in 15°18′ N., 107°18′ W., at 10 p. m. of the 1st. Northeast to southeast gales of decreasing intensity continued until about 6. a. m. of the 2d. The cyclone, apparently blocked from northward movement by high pressure, took an unusual southwesterly course and appears to have persisted until the 3d, although no strong winds were reported after the 2d.

Tehuantepecers.—In the Gulf of Tehuantepec, norther-type gales of force 7 were reported on the 4th and 5th, and of force 10 on the 15th, 16th, and 17th.

Fog.—Isolated occurrences of fog were observed on the 3d and 4th about midway along the San Francisco-Honolulu route; on the 8th and 9th south of the Aleutian Islands; and on the 9th to 11th near 45° N., 140° to 150° W. It was reported on 7 days off or near the California coast, and on 1 day off the middle coast of Lower California.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST

BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Typhoon, November 2–10, 1940.—The weather maps of November 2 had indications of a disturbance somewhere southeast of Guam. The fall in pressure shown on the afternoon map indicated clearly that this disturbance was of typhoon strength and the extra evening observations supplied by Mr. Lewis Stroup, stationed at the Commercial Pacific Cable office in Guam, showed that the storm was approaching the locality of the island. On November 3, the center passed close to and south of the island, moving in a northwesterly direction. It continued along a course, either northwest or west-northwest, to the regions near longitude 135° E., where it inclined to the north. November 6 and the two following days, the center recurved to the northeast. November 9, it was located very close to and southeast of the Bonins. A few ships' reports of November 10, showed that the center was far to the east-northeast of the Bonins (Ogasawaras), moving east-northeast or northeast toward the date line.

The typhoon center passed very close to and south of the office of the Commercial Pacific Cable Company in Guam. It is possible that the center passed over the island itself, but no reports that any of the villages on the island experienced the calm center have reached this office up to the time of writing this article. The minimum pressure occurred at 1.45 p. m. Guam time, and was 716.69 mm. (955.5 mb.), gravity correction applied. The winds were east at the time, with a velocity estimated over 125 m. p. h. For about 10 or 15 minutes, about the time of the minimum, according to Mr. Stroup, there was a lull in the wind, decreasing to about 80 m. p. h. (estimated). About 20 minutes before the minimum, the barometer was pumping, which continued until after the barometer reached its minimum. Mr. Stroup supplied the Observatory with many observations as the storm progressed and the series is given here, but in a brief form:

November 2, at 8 p. m., Guam time, pressure 750.60 mm. (1000.7 mb.) winds NNE, force 6; 10 p. m., 750.18 mm. N winds, 30 m. p. h.; midnight, 748.68 mm., NNW winds, 30 m. p. h.; November 3, 4 a. m., 745.10 mm., N winds, 48 m. p. h. squally; 5 a. m., 743.90 mm. N winds, 42 m. p. h.; 6 a. m., 743.80 mm., N winds, 42 m. p. h.; 7 a. m., 742.70 mm., NNE winds, 50 m. p. h.; 8 a. m., 741.83 mm., NNE winds 60 m. p. h., raining hard last two hours; 9 a. m., 740.68 mm. (987.5 mb.), NNE winds, 70 m. p. h.; 10 a. m., 737.28 mm. (983.0 mb.), NNE winds, 80 m. p. h.; 11 a. m. 731.65 mm. (975.5 mb.), NNE winds, 108 m. p. h.; anemometer ceased recording but cups can be seen revolving; noon, 724.62 mm. (966.1 mb.), NNE winds estimated more than 125 m. p. h.; 12.15 p. m., winds definitely NE; approximately 1.15 p. m. wind has changed to E, anemometer mast is down; approximately 1.25 p. m. 716.86 mm. (955.8 mb.) wind shifting ENE to E, terrific, barometer pumping; 1.45 p. m., minimum pressure 716.69 mm. (955.5 mb.) (28.22 inches), wind E terrific, then notably diminishing and becoming gusty; 2 p. m., 717.93 mm. (957.1 mb.), E winds, hurricane force; 3 p. m., 720.04 mm. (960.0 mb.) E to ESE, violent. After 3 p. m. no more extra observations were requested. The anemometer cups, it may be added, had been in use on station since 1918.

The loss of life was very small, considering the duration of these strong winds. From private sources, the writer learned that about five persons were missing after the storm, and it is supposed that they were drowned. Besides, two or three persons were killed when trees crashed down upon their houses. The property loss was enormous. Very few buildings were left undamaged. The greatest damage occurred with the east quadrant winds during the afternoon, after the center had passed.

On November 9, when the center was not very far from the Bonins, pressure at that station (the morning observation) was 729.5 mm. (972.6 mb.) with north-northwest winds force 5. At this time the storm center was moving east-northeast or northeast after recurvature.

The upper winds over Guam before the typhoon arrived were from the east quadrant. October 29 and following days, gradually backing, day after day, to the northeast and finally, on November 2, morning ascent, becoming north and north-northeast. Velocities were seldom over 30 k. p. h. before November 1, and never over 40 k. p. h. until after November 1, morning ascent. On the morning of November 2, the upper winds, as reported from the Navy station, were as follows—200 m., direction 10°, velocity 47 k. p. h.; 500 m., 10°, 49 k. p. h.; 1,000 m., 20°, 50 k. p. h., 1,500 m., 20°, 42 k. p. h. 2,000 m., 30°, 6 k. p. h. Balloon obscured. (Direction 360°, N—90° E, etc.) Very strong southeast quadrant winds were reported November 4 and 5 after the storm center had passed.

Over the Philippines, at Zamboanga, there was a shift to the southwest quadrant, the velocities never reaching 30 k. p. h., October 30 and 31. It seems as though there was a tendency to change to the southwest because of the distant forces which caused the typhoon to form. November 2 and the following days, Zamboanga again had east quadrant winds aloft, but changing to the southwest and northwest quadrants just when the typhoon center was recurving (November 5 and 6). Northeast and east quadrant winds prevailed over the other Philippine stations. None of the other reports at hand seem to have any interesting aspects to be mentioned. However the data from Netherlands East Indies and the Straits Settlements (which cannot be received by radio at the Observatory) should show more points of interest.

As this is written, November 20, it must be remarked that since late in September 1940, there has not been any typhoon close to the Philippines, excluding a small,

active center which formed over the China Sea and moved into the Continent during October. This is extraordinary for this time of the year. It is having its effect in a shortage of rain over various provinces of the Philippines, and the rice crop is not as plentiful as it might be. The typhoon activity continues to take place far to the east of the Archipelago, continuing the October 1940 conditions.

ADDITIONAL REPORT

Depression, November 25–30, 1940.—Pressure at Yap was rising and winds were veering toward the southeast during the afternoon of November 25, indicating the presence of a disturbance east of Mindanao. November 26, there was a depression about 120 miles east-northeast of Catanduanes Island, moving northwesterly. The fall in pressure over Samar and southern Luzon gave the impression that the storm was intensifying, but evening observations showed that this process did not continue. The center moved toward the eastern part of the Balintang Channel, where it recurved to the northeast. Apparently the depression was of minor importance, and if it were violent, it was such only over a very small area.

About four or five days previous to November 25, the east quadrant winds over Guam increased to values as high as 60 k. p. h. at a few levels, and in general showing a current flowing about 40 to 50 k. p. h. Over the Philippines, winds from the northeast and east quadrants existed until November 25, but the velocities were never over 30 k. p. h. A weak northeast quadrant current was flowing over Manila, Cebu, and Zamboanga November 25, and backing to the north and northwest during the afternoon. November 26 and 27, weak winds from the west and southwest quadrants were reported over Zamboanga and Cebu. Above 3,000 meters over Zamboanga there was an easterly current veering to the southeast, November 27. Manila's upper winds backed from east to north-northwest during these days. On November 28, all directions were from the northeast and east quadrants. The velocities were never over 45 k. p. h. during these days. When the center was east of northern Luzon and about to recurve, Aparri reported northeast and north winds, with velocities about 50 k. p. h. at various levels. It seems from available data that the air was attracted toward the center, an impression that might be changed when ascension reports from southern regions are received.

FLOOD LOSSES AND SAVINGS FOR THE YEAR 1939

BENNETT SWENSON

[Weather Bureau, Washington, January 1941]

Estimated flood losses for the year 1939 and savings reported as the result of warnings are tabulated below. The total loss has been estimated at $13,833,806, with a saving of more than $2,000,000. A total of 83 lives were lost.

The year 1939, except for one or two instances, was free from severe floods. The most severe single flood probably was the flash flood in eastern Kentucky on July 4 and 5. In this flood, which occurred in the mountain streams in the upper Licking and Kentucky River basins, 78 lives were lost, and an estimated monetary loss of more than $1,700,000 was suffered in four counties.

Estimated flood losses and savings for 1939

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total	Lives lost	Reported savings as the result of warnings
ST. LAWRENCE								
Grand River in Michigan					$11,100	$11,100		
ATLANTIC SLOPE								
Tioughnioga and Chenango Rivers	$125	$1,000			700	1,825		$1,700
Chemung River	4,000	600			5,000	9,600	2	15,000
Susquehanna River	43,350	100		$500	900	44,850		31,200
Roanoke River	340	25,000	$37,500	3,000	37,740	103,580		77,200
Tar River	100	18,000	22,500	3,000	4,740	48,340		15,500
Neuse River	2,500	18,000	30,500	3,200	14,740	68,940		22,000
Cape Fear River	500	22,000	23,500	3,200	5,740	54,940		35,500
Peedee River	16,500		55,000	2,000	8,000	81,500		36,000
Saluda River	3,680	400				4,080		11,500
Broad River, in South Carolina		50	150			200		1,300
Congaree River				100	510	610		2,150
Catawba-Wateree River	300		10,000	1,000	3,800	15,100		31,700
Santee River	3,500			3,000	6,000	12,500		7,500
Savannah River	500			750	10,000	11,250		100,000
Ogeechee River				100	2,000	2,100		5,000
Altamaha River	9,500		12,750	5,800	23,150	51,200		112,575
EAST GULF OF MEXICO								
Flint River	([1])				50	50		1,000
Apalachicola River	2,000	1,000		1,500	6,760	11,260		9,000
Choctawhatchee River	24,050	510,700	250	700	500	536,200		4,100
Conecuh River	31,950	250,000	50,000	270	3,300	335,520		1,850
Alabama River	631,000	1,108,000	420,000	49,000	6,500	2,214,500		71,000
Black Warrior-Tombigbee River						[2]3,545,600		15,200
Pearl River	9,770	1,000	7,900	5,450	12,650	36,770	1	47,500
MISSISSIPPI SYSTEM								
Upper Mississippi Basin								
Chippewa River	1,650					1,650		
Wisconsin River	1,375		300		3,400	5,075		67,500
Rock River					200	200		
Iowa River	2,600	200				2,800		
Des Moines River	9,350	790	3,940	100	2,220	16,400		15,400
Salt River			71,000		5,500	76,500		
Illinois River	2,100					2,100		
Meramec River	15,150	200	40,600	75	6,500	62,525		32,600
Mississippi River above Cairo, Ill.	43,275	500	14,875	200	1,650	60,500		45,700
Missouri Basin								
Big Muddy River	5,000					5,000		
Mills River	150,000			50,000		200,000		
Solomon River	42,750	3,000	31,200	4,000	2,000	82,950		17,000
Big Blue River	12,000					12,000		
Grand River in Missouri	55,000	1,200		900		57,100		20,000
Missouri River	36,250	31,525	159,850	7,500	17,200	252,325		127,100
Ohio Basin								
Allegheny River					500	500		20,000
Monongahela River	23,000			10,000	3,000	36,000		20,000
Little Kanawha River	21,800			1,000		22,800		
Olentangy River			10,000			10,000		
Scioto River			52,000			52,000		
Licking River						[2]1,365,000	27	
Kentucky River						[2]350,000	51	
Green River	13,800	1,000	7,700		32,000	54,500		93,000
White River in Indiana	48,075		150,300	1,000	43,550	242,925		137,000
Wabash River	173,650	3,500	341,370	11,800	41,800	572,120	2	292,700
Cumberland River						[2]638,640		168,100
Ohio River	105,700	2,500	159,100	5,600	155,400	428,300		468,000
White-Arkansas Basin								
Black River	1,500		500			2,000		
White River	50		6,600		2,600	9,250		
Cowskin and Big Slough Creeks in Kansas			45,000			45,000		
Ninnescah River			5,000			5,000		
North Canadian River	14,800	7,500	22,950			45,250		5,000
South Canadian River	28,000	4,100	4,000			36,100		
Poteau River	5,000	3,000	2,800		1,500	12,300		
Petit Jean River	350			100		450		500
Arkansas River	2,000		20,000		2,000	24,000		5,000
Red Basin								
Sulphur River								1,100
Ouachita River	3,000		2,000	1,900	15,300	22,200		104,000

[1] Figures not available. [2] Furnished by U. S. Engineer Office.

Estimated flood losses and savings for 1939—Continued

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total	Lives lost	Reported savings as the result of warnings
Lower Mississippi Basin								
St. Francis River	60,250		1,205,000	6,000	51,850	1,323,100		170,525
Tallahatchie River			125,000			125,000		
WEST GULF OF MEXICO								
Trinity River	800		1,500	75		2,375		12,000
Colorado River	350,000					350,000		
Rio Grande	5,800	1,500				7,300		
GULF OF CALIFORNIA								
Colorado Basin								
Gila River	12,950					12,950		
Total						13,833,806	83	2,278,300

RIVER STAGES AND FLOODS

By BENNETT SWENSON

Heavy rains and floods occurred in eastern Texas during November 1940. The floods were confined mainly to the Sulphur, Sabine, Neches, and Trinity Rivers and the lower portions of the Brazos, Colorado, and Guadalupe Rivers. The overflow was quite extensive but losses were minimized somewhat due to the fact that most of the crops had been harvested.

For several days, November 22 to 26, low pressure persisted over southern Texas, with an extensive mass of dense, polar air to the north. This resulted in widespread precipitation from eastern Texas, northward to Kansas and southeastern Missouri.

Some of the 24-hour amounts in Texas were as follows: In the Sulphur River drainage, Ringo Crossing, 2.50 inches on the 23d and 0.62 on the 24th, Naples, 2.00 inches on the 23d and 1.67 on the 24th; in the Sabine Basin, Logansport, La., had 11.33 on the 23d and 4.67 on the 24th; Rockland, in the Neches watershed, had 5.75 on the 24th and 3.27 on the 25th; in the Trinity Basin, Trinidad, had 2.60 on the 23d and 2.58 on the 24th; and Long Lake, 8.21 and 9.26, on the same dates; in the Brazos watershed, Valley Junction, had 4.95 and 3.19 on the 23d and 24th, Washington, 9.60 and 2.68; and Hempstead, 16.00 and 4.46, on the 24th and 25th; and in the Colorado Basin, Columbus, had 4.11 and 7.35 on the 24th and 25th.

Generally over the country, the precipitation during the month was well above normal in much of the Great Basin in the West and east of the Rocky Mountains except the extreme Southeast. Accounts of the floods are given below:

Atlantic Slope Drainage.—Light to moderate floods occurred in the lower portions of the Roanoke, Neuse, and Cape Fear Rivers from the 15th to the 25th but no damage was reported.

The stages in the Pee Dee River were high near the middle of the month, but did not reach flood stage at any point.

A rise occurred in the Broad and Santee Rivers on the 14th. Flood stage was reached at Blairs, S. C., on the 14th and at Rimini, S. C., the stage in the Santee River was slightly above flood stage on the 16–17th.

Red River Basin.—Heavy rains on the 22–24th in the watersheds of the Ouachita and the Little Missouri Rivers resulted in a flood stage in the Ouachita River at Arkadelphia, Ark., on the 24th. The crest stage was 18.2 feet, 1.2 foot, above flood stage on the same day. The loss in Ouachita County has been estimated at $1,000.

West Gulf of Mexico Drainage.—Heavy rains were general from November 21 to 26 over the upper Red River watershed and caused all of the streams to rise rapidly. However, flooding occurred only in the Sulphur River. At Ringo Crossing, Tex., a stage of 26 feet was reached on the 26th and at Naples, Tex., a stage of 27.4 feet on the 29–30th. The losses from this flood have been estimated at $4,300.

Precipitation was excessive over portions of the Sabine, Neches, Trinity, and Brazos Rivers, as discussed elsewhere in this report, and the resulting floods were moderate to heavy. As the stages were still above flood stage at the close of the month a further report will be made on these floods.

In the lower watersheds of the Colorado and Guadalupe Rivers excessive rains caused floods from November 24 to 29. Crest stages in the Colorado were 36.5 feet at Columbus, Tex., on the 25th and 35.3 feet at Wharton, Tex., on the 26th where the flood stages are 24 and 26 feet, respectively. In the Guadalupe River a crest of 28.5 feet (7.5 feet above flood stage) occurred at Victoria, Tex., on the 26th. Losses have been estimated at $82,000 in the Colorado River and $7,500 in the Guadalupe River.

Pacific Slope Drainage.—Light flooding on November 29 in the Santiam River was confined to the bottom lands. No material damage was reported.

FLOOD-STAGE REPORT FOR NOVEMBER 1940

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
James: Columbia, Va	10	15	15	10.3	15
Roanoke:					
Weldon, N. C	31	15	18	34.8	16
Williamston, N. C	10	20	25	10.7	23
Neuse:					
Neuse, N. C	14	16	18	15.2	17
Smithfield, N. C	13	17	19	14.0	19
Haw: Moncure, N. C	20	15	15	20.5	15
Cape Fear: Lock No. 2, Elizabethtown, N. C	22	16	18	24.7	17
Broad: Blairs, S. C	14	14	14	14.0	14
Santee: Rimini, S. C	12	16	17	12.4	17
MISSISSIPPI SYSTEM					
Red Basin					
Ouachita: Arkadelphia, Ark	17	24	24	18.2	24
Sulphur:					
Ringo Crossing, Tex	20	11 23	14 30	23.0 26.0	11 26
Naples, Tex	22	27	[1]	27.4	29-30
WEST GULF OF MEXICO DRAINAGE					
Sabine: Logansport, La	25	24	[1]	35.9	27
Neches: Rockland, Tex	22	26	[1]	25.5	30
Trinity:					
Dallas, Tex	28	25	28	32.4	26
Trinidad, Tex	28	24	[1]	34.6	27
Long Lake, Tex	40	25	[1]	46.0	28
Riverside, Tex	40	26	27	40.1	27
Liberty, Tex	24	25	[1]	26.9	29-30
Brazos:					
Waco, Tex	27	26	26	27.2	26
Valley Junction, Tex	44	25	27	47.4	26
Washington, Tex	45	27	[1]	47.6	29
Hempstead, Tex	40	24	[1]	------	------
Richmond, Tex	35	26	[1]	38.7	28
Colorado:					
Columbus, Tex	24	24	25	36.5	25
Wharton, Tex	26	25	27	35.3	26
Guadalupe:					
Gonzales, Tex	20	6 24	6 24	21.0 20.4	6 24
Victoria, Tex	21	6 26	10 29	27.1 28.5	9 26
PACIFIC SLOPE DRAINAGE					
Columbia Basin					
Santiam: Jefferson, Oreg	10	29	29	10.3	29

[1] Continued into following month.

CLIMATOLOGICAL DATA

[For description of tables and charts, see REVIEW, January, pp. 32 and 38]

CONDENSED CLIMATOLOGICAL SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Section	Temperature: Section average	Temperature: Departure from the normal	Monthly extremes: Station	Highest	Date	Monthly extremes: Station	Lowest	Date	Precipitation: Section average	Precipitation: Departure from the normal	Greatest monthly: Station	Amount	Least monthly: Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	54.7	+0.3	Greensboro	85	3	5 stations	12	16	3.49	+0.08	Bishop	8.38	Mitchell Dam	1.56
Arizona	48.4	−2.2	Florence	90	1	2 stations	1	[1] 13	1.16	+.16	Oracle	4.13	Yuma	T
Arkansas	49.3	−2.0	3 stations	82	[1] 2	Gilbert	3	15	5.93	+2.14	Spring Bank	11.51	Blytheville	2.75
California	50.1	−2.1	2 stations	91	[1] 2	Ellery Lake	0	4	1.42	−.92	Lake Spaulding	8.73	8 stations	.00
Colorado	32.1	−3.0	do	81	2	Fraser	−24	[1] 13	1.01	+.23	Wolf Creek Pass	3.44	2 stations	.07
Florida	65.0	+.1	do	91	1	Mason	15	16	1.20	−.97	Pensacola	8.24	4 stations	.00
Georgia	54.5	.0	Quitman	86	11	Blairsville	10	16	3.73	+1.10	Blakely	7.76	Brunswick	.55
Idaho	31.1	−4.3	Oakley	68	1	3 stations	−15	[1] 12	2.03	.00	Roland	6.72	Mud Lake	.13
Illinois	40.2	−1.9	Fairfield	82	3	Freeport	−3	28	2.89	+.30	2 stations	6.03	Roberts	1.16
Indiana	40.9	−1.4	Tell City	86	3	Wheatfield	1	28	3.59	+.55	Newburg	5.69	Winamac	1.95
Iowa	33.6	−2.7	Shenandoah	78	3	Inwood	−12	14	2.45	+.84	Cresco	4.19	Mount Pleasant	1.11
Kansas	40.4	−2.8	Richfield	86	2	Oberlin	−19	14	2.66	+1.37	Sedan	5.48	Sharon Springs	.39
Kentucky	45.8	−.6	6 stations	80	[1] 3	Lynch (near)	6	16	3.70	+.30	Bowling Green	5.87	Jenkins	1.46
Louisiana	58.7	−.1	2 stations	87	4	2 stations	17	[1] 15	8.21	+4.30	Logansport	20.85	New Orleans	1.21
Maryland-Delaware	45.5	+.3	Western Port, Md.	77	4	Mount Savage Summit, Md.	14	28	4.98	+2.43	Snow Hill, Md.	6.70	Mount Savage Summit, Md.	2.35
Michigan	34.6	−1.5	South Haven	67	4	Kenton	−15	15	3.22	+.71	Delaware	6.35	Channing	1.28
Minnesota	25.5	−4.0	St. Peter	67	3	Big Falls	−26	28	2.59	+1.42	Pigeon River Bridge	5.70	Moorhead	.52
Mississippi	54.3	−.7	Hattiesburg	84	4	Rochdale	13	16	5.64	+2.02	Holly Bluff	12.41	Biloxi	1.23
Missouri	42.2	−2.1	Marble Hill	83	2	2 stations	−2	[1] 14	3.46	+.77	Doniphan	6.75	Stovar	1.28
Montana	25.2	−6.9	2 stations	68	2	White Water	−34	12	1.13	+.11	Haugan	3.57	Choteau	.12
Nebraska	33.6	−3.6	Falls City	79	3	Nenzel (near)	−29	14	1.06	+.30	McCool	3.63	Lodgepole	T
Nevada	37.9	−2.0	Alamo	86	14	Wells	−11	23	.52	−.11	Lewers Ranch	2.02	Thorne	.00
New England	37.8	−.2	2 stations	74	5	Chelsea, Vt.	−10	29	5.90	+2.44	Portsmouth, R. I.	8.94	Burlington, Vt.	2.67
New Jersey	43.5	−.2	do	76	[1] 5	Layton	10	[1] 26	4.66	+1.46	Pleasantville	5.62	Charlotteburg	3.60
New Mexico	39.9	−2.5	Rodeo Airport	82	2	Eagle Nest	−10	[1] 14	1.70	+1.04	Porter (near)	5.60	Shiprock	.17
New York	38.0	.0	Wappingers Falls	77	5	Stillwater Reservoir	−12	29	3.78	+.78	Cutchogue	8.61	Ithaca No. 2	1.59
North Carolina	50.1	+.2	Fayetteville	83	4	Mount Mitchell	0	15	4.19	+1.52	Salisbury	7.45	Clinton	1.07
North Dakota	22.0	−4.6	New England	59	1	Parshall	−28	13	.59	.00	2 stations	1.09	Alpha	.17
Ohio	40.7	−.7	Ironton	81	4	McArthur	8	16	3.45	+.74	Wilmington	4.74	Bowling Green	1.60
Oklahoma	46.7	−3.0	Fort Supply Dam	83	4	Hooker	−3	13	4.75	+2.69	Idabel	8.64	Buffalo	2.41
Oregon	37.1	−3.3	Wasco	76	9	Meacham	−10	13	3.27	−.37	Valsetz	12.58	Bend	.56
Pennsylvania	41.3	.0	Palmerton	78	5	2 stations	9	[1] 26	4.04	+1.18	Kane Airway Station.	5.86	Lawrenceville	1.93
South Carolina	53.8	.0	McColl	84	1	do	14	16	4.13	+1.78	Newberry	7.36	Beaufort (near)	1.46
South Dakota	28.3	−4.8	Armour	75	3	Ottumwa	−25	14	.67	+.05	Menno	1.98	Ashton	.06
Tennessee	47.6	−.9	Union City	82	3	Waynesboro	8	16	3.52	−.02	Dickson	7.97	Etowah	1.41
Texas	54.8	−2.3	Rio Grande	98	4	Spearman	0	13	6.22	+4.04	Hempstead	25.57	Rio Grande	.12
Utah	34.1	−3.3	2 stations	73	[1] 1	Woodruff	−13	24	1.25	+.32	Silver Lake (Brighton).	4.35	Callao	.01
Virginia	47.1	+.5	do	83	[1] 4	Mountain Lake	11	9	4.27	+1.81	Clarksville	5.89	Wytheville	1.28
Washington	35.8	−3.9	Startup	70	26	Chesaw	−4	11	3.97	−.95	Big Four	15.99	Rock Island	.85
West Virginia	43.2	.0	2 stations	80	4	Seneca State Forest	4	29	3.27	+.53	Kearneysville	6.38	Kenawha Falls	1.20
Wisconsin	31.0	−2.8	4 stations	68	3	Solon Springs	−20	28	3.35	+1.49	Stanley	5.77	Beloit	1.95
Wyoming	26.6	−4.9	Torrington	75	2	2 stations	−29	12	.96	+.26	Bechler River	4.98	2 stations	.07
Alaska (October)	33.0	+2.9	View Cove	66	18	Ophir	−14	23	3.56	.00	Latouche	34.64	Fort Yukon	.09
Hawaii	73.1	+1.8	5 stations	91	[1] 3	Haleakala (Maui)	35	3	7.04	−.84	Kukus (Maui)	28.00	Halaula (Kauai)	1.12
Puerto Rico	76.6	+.3	2 stations	96	2	Lares	57	29	6.63	−.40	La Mina (El Yunque).	18.78	Ensenada	1.91

[1] Other dates also.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							40.3	+0.8										79	5.18	+1.9										7.1		
Eastport	75	67	85	29.92	30.01	0.00	37.4	+.7	53	12	43	10	29	32	22	35	33	83	4.37	+1.0	17	11.0	nw.	33	e.	3	8	3	19	7.2	8.9	3.8
Greenville, Maine	1,070	6		28.84	30.04		31.1		54	12	37	4	29	25	24	29	26		5.51		19											4.0
Portland, Maine [2]	103	82	117	29.92	30.03	+.02	37.4	−.6	62	22	46	5	29	29	30	33	30	85	5.52	+2.1	16	8.1	w.	33	nw.	25	7	8	15	6.3	5.4	1.6
Concord [2]	289	54	72	29.74	30.06	.00	38.5	+.8	66	22	46	5	29	31	28	33	30	80	5.93	+2.8	18	6.3	nw.	23	w.	22	4	7	19	7.2	9.3	6.8
Burlington [1]	403	11	48	29.60	30.05	.00	35.5	−.8	63	5	42	2	29	30	26	33	29	80	2.67	+.0	14	10.6	s.	35	s.	11	2	5	23	8.4	5.2	2.3
Northfield	876	12	60	29.09	30.06	−.02	34.7	+1.9	68	5	42	−3	29	27	36	30	27	82	3.33	+.4	21	7.7	n.	27	s.	11	3	6	21	8.1	6.6	5.4
Boston [1]	124	33	62	29.93	30.07	+.02	42.9	+.9	71	5	50	17	29	36	22	38	33	72	6.24	+2.9	14	11.8	w.	43	sw.	12	6	7	17	6.9	8.5	5.0
Nantucket	12	14	90	30.06	30.08	+.03	45.0	+.6	61	5	50	25	29	40	19	42	38	79	5.22	+2.0	10	15.1	w.	38	e.	27	6	6	18	7.1	1.2	.0
Block Island	26	11	46	30.05	30.08	+.02	45.0	+.4	60	12	50	24	26	40	19	42	37	74	6.37	+2.7	11	18.8	w.	45	e.	27	9	10	11	5.6	2.5	.0
Providence [2]	159	65	25	29.91	30.09	+.02	42.9	+2.5	69	22	50	19	26	36	23	37	33	76	6.38	+3.3	11	12.3	nw.	43	nw.	3	8	5	17	6.9	6.5	3.0
Hartford [1]	159	5	44	29.92	30.09	+.01	41.2	+1.7	69	22	49	13	29	33	27	37	33	79	5.46	+1.9	11	8.7	n.	29	n.	25	5	6	19	7.4	5.0	4.2
New Haven [2]	107	74	68	29.98	30.10	+.03	43.0	+1.0	66	22	49	21	26	37	23	39	35	76	5.45	+2.1	10	9.6	n.	35	s.	12	6	10	14	6.7	3.7	T
Middle Atlantic States							45.8	+1.0										72	4.11	+1.6										6.7		
Albany [1]	97	26	40	29.97	30.07	−.01	38.2	−1.1	65	5	45	13	29	31	25	35	31	77	3.13	+.4	15	10.3	nw.	32	s.	12	3	7	20	8.1	4.9	2.2
Binghamton	871	57	79	29.16	30.11	+.02	39.0	+.3	71	4	46	14	29	32	38	35	32	79	2.48	+.1	17	7.4	nw.	26	nw.	3	0	4	26	8.9	8.1	4.4
New York	314	415	454	29.76	30.10	+.01	44.8	+.6	68	5	51	24	26	39	20	40	35	70	3.91	+1.0	12	16.7	nw.	50	nw.	28	4	7	19	7.3	.9	.0
Harrisburg [1]	374	30	49	29.73	30.14	+.03	43.6	+.8	74	5	51	23	26	36	36	39	34	72	4.22	+2.0	11	9.0	nw.	28	se.	11	3	7	20	7.5	2.5	0.5
Philadelphia [2]	114	174	367	30.01	30.14	+.04	46.4	+.7	71	22	53	25	26	40	24	40	36	77	4.24	+1.5	12	13.4	n.	38	s.	12	2	12	16	7.1	T	.0
Reading	323	47	306	29.78	30.14		44.0	+1.5	74	5	51	24	26	37	30	39	33	68	4.86	+2.1	12	12.8	nw.	36	nw.	6	3	11	16	7.2	2.0	.9
Scranton	805	72	104	29.22	30.11	+.02	40.4	−.1	71	5	47	17	26	34	29				3.05	+.3	15	7.3	sw.	26	nw.	28	3	7	20	7.9	7.0	4.0
Atlantic City	52	37	172	30.08	30.14	+.04	47.4	+1.8	66	22	54	26	26	41	23	43	38	73	4.82	+2.0	9	16.4	w.	43	e.	26	6	10	14	6.7	.0	.0
Sandy Hook	22	10	57																													
Trenton	190	89	107	29.91	30.12		44.3	−.1	71	22	51	23	26	38	26	40	34	70	3.96	+1.2	11	9.3	s.	26	nw.	12	3	7	20	7.5	T	.0
Baltimore [2]	123	100	215	30.02	30.15	+.04	48.4	+2.1	76	22	55	27	26	41	27	42	36	62	5.99	+3.4	10	11.1	sw.	33	sw.	28	7	7	16	6.4	T	.0
Washington	112	62	85	30.02	30.15	+.03	48.2	+3.0	75	22	55	28	26	41	31	41	35	65	5.26	+2.9	9	7.7	nw.	27	nw.	6	9	10	11	5.7	T	.0
Cape Henry	18	8	54	30.13	30.15		52.8	+.7	77	22	60	31	29	46	25	47	43	75	5.15	+2.8	8	13.7	sw.	35	n.	12	9	12	9	5.4	T	.0
Lynchburg	686	144	194	29.43	30.19	+.06	49.3	+2.1	75	22	58	27	29	40	37	42	35	65	4.40	+2.1	9	7.8	nw.	27	nw.	6	10	7	13	5.7	.0	.0
Norfolk [2]	91	80	125	30.07	30.17	+.06	52.8	+1.4	76	22	61	33	16	45	27	46	42	81	4.45	+2.3	7	10.5	w.	27	e.	27	9	9	12	5.8	T	.0
Richmond [2]	144	11	52	30.01	30.16	+.04	49.5	+1.2	75	22	59	28	29	40	33	41	37	78	4.58	+2.4	8	8.7	sw.	21	w.	5	13	8	9	4.7	.0	.0
Wytheville	2,304	49	55	27.74	30.19	+.06	44.0	+1.0	72	4	53	20	15	35	37	38	33	72	1.28	−.9	9	7.5	w.	25	w.	29	9	9	12	5.8	.1	.0
South Atlantic States							55.2	+1.0										79	2.86	+0.4										5.5		
Asheville	2,253	89	104	27.82	30.23	+.09	46.4	+1.3	74	22	57	18	16	36	37	40	35	71	1.36	−.9	7	9.2	nw.	31	s.	11	10	3	17	6.1	T	.0
Charlotte [2]	779	63	86	29.33	30.17	+.04	52.0	+1.4	78	4	61	26	16	42	30	44	40	78	5.50	+2.9	8	6.5	sw.	17	se.	11	11	3	16	6.0	.0	.0
Greensboro [1]	886	6	56	29.23	30.19		48.4		77	4	60	22	29	37	38	42	38	79	5.62		10	8.0	sw.	24	ne.	13	12	6	12	5.4	T	.0
Hatteras	11	5	50	30.15	30.16	+.05	56.8	+.5	74	22	64	35	29	50	23	53	50	83	4.17	+.7	10	12.4	n.	34	nw.	27	13	4	13	5.1	.0	.0
Raleigh [2]	376	103	146	29.77	30.18	+.05	52.3	+1.3	80	4	62	28	16	43	29	44	40	73	4.02	+1.9	9	9.2	w.	25	se.	11	11	7	12	5.3	.0	.0
Wilmington	72	73	107	30.10	30.18	+.06	56.1	+.1	78	23	66	28	16	46	29	50	47	78	1.86	−1.0	11	8.2	nw.	22	se.	11	14	4	12	5.0	.0	.0
Charleston [2]	48	11	92	30.12	30.17	+.05	59.0	+.9	79	12	67	28	16	51	26	49	47	85	1.54	−.6	11	9.3	n.	24	ne.	25	12	4	14	5.1	.0	.0
Columbia, S. C. [2]	347	70	91	29.81	30.19	+.07	54.4	+.4	80	3	64	26	16	44	34	47	44	79	4.42	+2.4	9	7.6	n.	23	s.	11	11	5	14	5.2	.0	.0
Greenville, S. C.	1,040	70	78	29.07	30.18		51.5	+1.9	80	3	61	22	16	42	36				3.42	+.2	10	6.4	ne.	21	n.	8	11	5	14	5.7	.0	.0
Augusta [2]	182	62	77	29.98	30.17	+.04	55.5	+1.0	82	3	66	24	16	45	38	48	42	74	3.78	+1.4	8	5.3	nw.	20	sw.	11	11	4	15	5.7	.0	.0
Savannah [2]	65	73	152	30.11	30.18	+.06	61.0	+2.5	82	3	71	25	16	51	31	52	49	82	1.12	−1.0	5	9.0	e.	26	nw.	27	12	4	14	5.3	.0	.0
Jacksonville [2]	43	86	110	30.12	30.17	+.07	62.4	+.2	84	1	72	25	16	52	32	53	51	84	.29	−1.7	7	7.1	ne.	19	nw.	27	8	10	12	5.6	.0	.0
Florida Peninsula							71.5	+0.5										78	0.80	−1.5										4.4		
Key West [2]	21	10	64	30.04	30.07	+.05	74.4	+.1	85	1	80	56	16	69	14	68	66	80	.76	−1.4	7	10.6	e.	30	nw.	15	18	7	5	3.7	.0	.0
Miami [2]	25	124	168	30.06	30.09	+.03	72.9	+1.1	85	1	78	44	16	68	24	64	61	78	1.48	−1.4	6	10.7	e.	26	ne.	3	10	10	10	5.2	.0	.0
Tampa [2]	35	88	197	30.10	30.13	+.05	67.2	+.3	85	1	77	31	16	57	28	59	56	77	.15	−1.6	2	11.9	e.	27	e.	4	11	14	5	4.3	.0	.0
East Gulf States							57.0	+0.1										76	4.43	+1.1										6.1		
Atlanta [1]	1,173	5	72	28.93	30.19	+.06	51.3		76	4	61	19	16	42	37	44	39	73	3.29		11	9.5	nw.	27	e.	26	11	3	16	6.0	.0	.0
Macon [2]	370	79	87	29.78	30.18	+.05	54.6	+.4	80	3	65	22	16	44	40	48	43	75	5.94	+3.4	12	6.2	nw.	21	s.	11	11	4	15	5.9	.0	.0
Thomasville	273	49	58	29.88	30.19	+.07	58.4	−.1	81	5	69	24	16	47	37				4.86		8										.0	.0
Apalachicola	35	11	51	30.12	30.16		61.4	+.1	79	1	69	29	16	54	29	56	53	80	1.45	−1.6	6	9.0	e.	24	se.	26	7	6	17	6.4	.0	.0
Pensacola	56	54	79	30.11	30.17	+.06	59.2	−1.0	76	2	67	25	16	52	28	54	50	75	8.24	+4.5	7	7.6	e.	20	s.	25	9	9	12	5.8	.0	.0
Anniston	741	9		29.41	30.22	−1.0	52.2	−.3	78	3	63	14	16	42	38				3.84	−.6	10		se.				14	6	10		.0	.0
Birmingham [2]	700	11	48	29.44	30.20	+.08	53.4	−.5	81	3	63	19	16	44	32	44	40	75	3.81	+.5	8	8.0	n.	36	se.	1	13	4	13	5.2	.0	.0
Mobile [2]	57	86	161	30.11	30.17	+.06	58.8	+.2	80	26	68	24	16	50	32	52	49	79	3.00	−.6	8	10.4	n.	28	nw.	13	6	11	13	6.4	.0	.0
Montgomery [2]	218	92	105	29.95	30.19	+.07	56.4	+.6	80	3	66	22	16	47	31	48	43	75	2.79	−.4	9	7.3	se.	21	w.	11	8	8	14	5.9	.0	.0
Meridian [2]	375	67	92	29.78	30.18	+.06	54.8	+.6	79	23	66	18	16	44	37	48	45	82	3.86	+.5	9	6.3	n.	22	se.	1	9	9	12	5.5	.0	.0
Vicksburg	247	82	102	29.90	30.17	+.05	56.2	+.4	81	4	65	22	15	48	32	49	44	70	9.53	+5.8	11	9.5	n.	36	sw.	11	9	6	15	5.9	.0	.0
New Orleans [2]	53	76	84	30.10	30.16	+.06	61.6	.0	81	4	69	32	15	54	25	55	50	73	1.21	−1.9	8	7.8	se.	21	se.	25	7	11	12	5.9	.0	.0
Port Eads, La	9	4	35	30.12	30.13		65.6		83	5	71	36	16	60	28				4.45		8	11.3	n.	29		25				7.8	.0	.0
West Gulf States							57.1	−0.7										78	7.1	+4.2										6.3		
Shreveport [2]	249	92	227	29.88	30.15	+.04	55.4	−.6	76	2	64	23	15	46	37	49	45	77	10.09	+6.4	11	11.3	se.	46	w.	11	7	9	14	5.9	.0	.0
Bentonville	1,303	12	51	28.80	30.19		46.0	−.7	76	2	57	8	15	36	39				3.52	−.5	9	8.0	s.	23	sw.	29	12	6	12	5.7	T	.0
Fort Smith	463	57	82	29.67	30.17	+.06	49.6	−1.4	77	2	59	18	15	40	36	43	37	68	4.64	+1.8	9	7.7	e.	35	w.	11	12	6	12	5.1	.0	.0
Little Rock [2]	357	94	102	29.78	30.17	+.05	51.0	−1.1	75	2	60	20	15	42	35	44	41	81	5.55	+1.4	11	8.0	s.	27	s.	10	12	3	15	5.8	.0	.0
Austin [2]	605	68	90	29.48	30.13		56.7	−1.8	79	23	66	28	14	48	43	51	48	80	5.07	+2.8	11	7.1	n.	25	nw.	10	9	4	17	6.2	.0	.0
Brownsville [2]	57	88	96	30.01	30.07		68.4	−1.2	88	5	75	38	15	61	25	62	60	82	2.34	+.4	11	11.2	se.	28	se.	19	4	10	16	7.0	.0	.0
Corpus Christi [2]	20	11	78	30.08	30.10	+.03	64.6	+.3	82	10	71	38	15	58	27	59	57	84	1.23	−.8	12	11.0	s.	26	s.	10	9	3	18	6.5	.0	.0
Dallas [1]	512	220	227	29.58	30.14	+.05	53.4		76	2	64	19	15	43	42	48	44	76	8.75	+6.2	10	10.8	n.	34	s.	18	10	2	18	6.4	.0	.0
Fort Worth [1]	679	35	56	29.42	30.14	+.04	53.1	−2.4	77	17	63	20	15	43	40	47	43	76	6.35	+3.8	10	11.4	s.	44	w.	11	11	3	16	6.3	T	.0
Galveston [2]	54	106	114	30.06	30.12	+.03	63.0	−.3	78	4	68	37	14	58	21	58	55	80	16.18	+12.8	9	11.1	n.	37	nw.	11	6	9	15	6.2	.0	.0
Houston [2]	138	157	190	29.98	30.13		61.6	+.6	81	10	69	30	14	54	29	55	52	82	9.06	+5.2	11	11.1	se.	30	ne.	24	8	5	17	6.3	.0	.0
Palestine	510	64	72	29.61	30.15	+.04	56.3	−.9	76	4	65	24	15	48	31	50	45	72	15.92	+12.5	11	7.7	n.	23	ne.	23	7	8	15	6.2	.0	.0
Port Arthur	34	59	134	30.11	30.14		60.6		81	4	67	29	15	54	29				8.58	+5.5	11	14.4	n.	41	se.	25	5	7	18	6.7	.0	.0
San Antonio [2]	693	111	301	29.38	30.12	+.04	59.4	+.9	80	21	68	29	15	51	32	54	50	78	2.40	+.5	10	11.9	e.	32	e.	11	8	5	17	6.7	.0	.0

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind								Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch, or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days			
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							44.8	−0.3										75	3.59	+0.5										6.5		
Chattanooga	762	21	54	29.37	30.20	+.06	48.0	−2.4	78	3	60	14	16	36	43	41	37	77	2.90	......	9	6.5	nw.	25	se.	11	11	3	16	5.9	0.0	0.0
Knoxville [2]	995	66	84	29.12	30.20	+.07	48.6	+.7	76	3	58	20	16	39	33	41	36	71	1.76	−1.3	7	5.7	ne.	23	sw.	11	11	7	12	5.4	T	.0
Memphis [2]	399	78	86	29.74	30.18	+.06	51.6	−.1	76	3	60	17	15	44	30	43	39	76	3.27	−1.0	12	7.8	s.	32	sw.	11	11	7	12	5.4	.0	.0
Nashville [2]	546	167	187	29.59	30.19	+.07	48.3	−.7	77	3	58	17	15	39	30	42	38	74	3.71	+.2	11	9.5	s.	41	se.	11	11	5	14	5.5	.0	.0
Lexington	989	6	.....	29.11	30.20	+.08	44.5	−.3	76	3	54	15	16	35	34	.....	.....	.....	3.58	......	11	......	......	.....	.....	.....	11	6	13	5.7	1.4	.0
Louisville [2]	525	106	120	29.60	30.17	+.05	46.6	−.1	76	3	55	19	14	38	29	39	34	71	3.98	+.4	11	10.3	sw.	50	sw.	11	10	6	14	5.9	T	.0
Evansville [1]	431	76	116	29.70	30.17	+.05	43.9	−2.7	76	3	54	16	14	34	36	39	34	73	4.76	+1.0	8	9.5	nw.	47	sw.	11	8	8	14	6.3	T	.0
Indianapolis [2]	823	98	129	29.24	30.15	+.05	41.7	+.6	75	3	49	16	14	34	34	35	31	78	3.33	.0	11	9.2	nw.	37	sw.	11	5	7	18	7.0	T	.0
Terre Haute	575	68	149	29.53	30.17	......	42.1	......	76	3	50	14	14	34	34	36	32	78	3.57	+.3	10	11.0	nw.	47	sw.	11	7	8	15	6.8	T	.0
Cincinnati [3]	627	11	51	29.48	30.17	+.05	43.9	+1.4	75	3	52	20	14	36	33	38	34	74	4.02	+1.2	11	9.1	w.	33	sw.	11	7	5	18	6.7	.4	.0
Columbus [2]	822	90	710	29.25	30.15	+.04	41.8	−.1	71	4	50	21	16	34	27	36	32	76	3.64	+.9	12	11.6	s.	53	sw.	11	7	4	19	7.2	.3	.0
Dayton	700	186	213	29.17	30.16	......	41.8	−.2	70	4	49	19	14	34	30	36	32	79	4.62	+1.8	10	12.3	sw.	47	s.	11	8	6	16	6.9	T	.0
Elkins [2]	1,947	61	78	28.08	30.18	+.06	41.4	+1.1	73	4	51	17	28	32	42	36	32	76	3.28	+.5	14	7.2	w.	28	se.	11	4	7	19	7.8	7.3	.0
Parkersburg	637	77	84	29.46	30.16	+.04	44.0	+.2	75	4	52	21	16	36	34	39	34	73	3.87	+1.3	12	7.3	se.	25	se.	11	8	7	15	6.6	7.1	.0
Pittsburgh [1]	842	39	54	29.22	30.13	+.03	41.2	−2.0	71	4	48	21	28	34	32	36	32	73	2.92	+.6	17	12.4	nw.	34	nw.	6	3	4	23	8.3	.3	T
Lower Lake Region							39.0	−0.3										79	2.77	0.0										8.1		
Buffalo [2]	768	243	279	29.22	30.08	+.03	39.2	+.2	66	11	45	20	26	34	24	35	32	80	4.38	+1.4	18	18.3	w.	57	sw.	12	3	5	22	8.1	17.5	5.5
Canton	448	10	61	29.56	30.05	......	34.1	+.2	67	5	42	−2	20	27	34	31	29	84	3.42	+.3	22	9.3	sw.	35	sw.	12	0	7	23	8.7	13.3	5.2
Ithaca	836	77	100	29.16	30.09	......	38.8	+.2	72	4	45	15	26	32	35	.....	.....	.....	1.73	−.6	17	11.4	nw.	40	s.	11	2	5	23	8.6	7.8	1.5
Oswego	335	71	85	29.69	30.07	+.02	39.4	+.5	66	5	45	19	28	34	24	36	32	74	2.60	−.7	19	11.8	se.	31	s.	11	0	6	24	8.7	7.6	4.8
Rochester [1]	523	86	102	29.59	30.08	+.03	38.9	+.2	69	4	45	16	28	33	32	35	32	80	2.98	+.4	19	11.0	w.	32	w.	22	4	5	21	8.3	13.5	5.1
Syracuse [3]	596	65	79	29.42	30.08	+.02	39.2	+.5	71	4	46	14	26	32	36	35	32	81	3.32	+.6	0	12.0	sw.	35	w.	3	0	5	25	8.9	12.9	2.4
Erie [2]	714	57	81	29.31	30.10	+.04	41.4	.0	70	4	47	22	26	36	23	37	33	79	2.81	−.5	17	11.1	w.	28	se.	11	2	6	22	8.5	7.7	.6
Cleveland [2]	762	267	318	29.27	30.12	+.06	41.8	+.9	71	4	48	22	28	35	29	36	31	74	2.19	−.4	14	18.8	nw.	59	sw.	11	3	5	22	8.1	3.9	T
Sandusky	629	5	67	......	......	......	40.0	−1.1	67	11	47	20	28	33	32	.....	.....	.....	2.28	−.1	15	11.5	sw.	40	sw.	11	5	4	21	7.6	4.4	.5
Toledo [2]	628	79	87	29.42	30.12	+.05	38.8	−1.6	67	11	46	19	14	32	33	33	30	80	2.37	.0	14	11.3	w.	38	w.	11	7	7	16	6.6	10.2	1.0
Fort Wayne [1]	857	69	84	29.18	30.13	......	38.4	−2.3	67	3	46	12	28	31	36	33	30	80	2.37	−.5	12	10.7	w.	53	sw.	11	6	7	17	6.9	3.8	.2
Detroit	730	218	78	29.29	30.10	+.04	38.0	−1.3	64	4	45	18	14	31	30	34	30	77	2.75	+.3	13	12.3	nw.	45	sw.	11	5	3	22	7.9	9.1	3.4
Upper Lake Region							33.8	−1.0										81	3.08	+0.7										8.1		
Alpena	609	13	89	29.36	30.05	+.04	34.2	−.2	58	4	40	15	14	29	27	32	29	84	3.22	−.4	21	12.5	nw.	47	sw.	11	1	8	21	8.6	8.4	4.9
Escanaba	612	54	72	29.36	30.05	−.02	32.8	−.3	53	5	38	8	15	27	32	31	28	82	3.01	−.9	16	11.6	nw.	43	s.	11	2	4	24	8.7	6.4	4.0
Grand Rapids [3]	707	70	244	29.30	30.08	+.03	37.8	−.6	64	11	44	18	28	32	38	33	30	82	[illegible]	+.2	15	13.6	sw.	65	sw.	11	3	8	19	7.8	17.3	14.2
Lansing	878	6	90	29.12	30.10	......	36.0	−1.5	62	11	43	13	14	29	32	32	30	83	3.11	+.6	13	10.4	sw.	41	sw.	11	3	7	20	7.9	13.2	12.0
Marquette	734	44	73	29.20	30.02	......	32.5	−.8	56	4	38	7	15	27	32	30	27	81	3.96	+1.0	21	8.8	w.	33	s.	11	0	3	27	9.3	10.4	5.2
Sault Sainte Marie [2]	614	11	52	29.34	30.03	+.02	30.6	−1.4	54	5	36	8	28	25	28	28	26	86	3.71	+1.0	20	9.2	se.	34	sw.	11	0	3	27	9.1	12.8	2.3
Chicago	673	7	131	29.37	30.12	+.05	38.6	−1.5	70	3	46	8	28	31	43	34	30	73	2.36	.0	12	12.2	nw.	42	sw.	11	6	7	17	7.0	14.8	2.8
Green Bay	617	109	141	29.37	30.06	+.02	33.2	−.8	57	5	39	10	28	27	37	30	26	76	3.25	+1.1	13	11.6	sw.	47	s.	11	5	4	21	7.8	12.9	12.4
Milwaukee [2]	681	126	221	29.33	30.08	+.03	36.3	−1.0	61	4	43	9	28	29	42	32	28	80	2.80	+1.0	11	14.6	w.	54	sw.	11	7	7	16	6.8	18.0	12.5
Duluth	1,133	5	47	28.79	30.05	+.01	25.8	−4.2	48	2	32	−7	28	19	28	24	22	83	3.40	+2.0	14	15.0	nw.	52	nw.	11	3	4	23	8.1	14.7	5.7
North Dakota							22.2	−4.6										84	0.58	−0.1										7.2		
Moorhead, Minn. [3]	940	50	58	29.07	30.14	+.07	24.4	−2.7	51	1	30	−6	14	18	30	22	20	85	.52	−.4	8	9.5	nw.	34	nw.	11	3	5	22	.....	6.3	4.1
Bismarck	1,677	17	43	28.32	30.18	+.11	22.6	−5.9	55	1	31	−19	13	14	39	20	17	82	.47	−.1	7	11.0	nw.	38	nw.	11	3	10	17	8.1	7.4	3.2
Devils Lake	1,478	11	44	28.51	30.15	+.09	21.2	−3.3	47	17	27	−15	13	15	30	20	18	90	.45	−.3	8	10.1	nw.	31	nw.	11	4	6	20	7.8	5.1	2.9
Grand Forks	832	12	67	29.20	30.14	......	22.4	−3.6	47	3	28	−8	13	16	26	.....	.....	.....	.83	......	10	......	nw.	.....	.....	.....	2	4	24	.....	5.9	2.3
Lemmon, S. Dak.	2,602	4	38	27.33	30.16	......	23.4	......	55	2	33	−24	13	14	52	20	17	.....	1.11	......	4	......	nw.	.....	.....	.....	9	4	17	.....	10.6	1.1
Williston	1,878	42	50	28.13	30.20	+.14	20.5	−6.7	48	1	28	−17	13	13	35	19	15	80	.90	+.3	8	7.1	nw.	24	se.	2	11	6	13	5.6	11.5	5.6
Upper Mississippi Valley							36.9	−1.8										78	2.83	+0.8										6.3		
Minneapolis-St. Paul, Minn. [1]	919	32	61	29.06	30.09	+.03	27.8	−4.6	62	3	35	−6	29	21	28	26	23	83	5.15	+3.9	12	10.6	nw.	38	w.	11	4	3	23	8.2	26.3	8.9
Springfield, Minn.	1,025	4	42	28.98	30.12	......	26.6	......	64	3	34	−5	14	20	27	25	23	.....	2.46	......	9	......	......	.....	.....	.....	.....	.....	.....	.....	.....	4.0
La Crosse [2]	714	11	48	29.30	30.09	+.05	32.0	−3.2	65	3	40	3	28	24	41	28	25	83	3.30	+1.7	13	6.1	w.	24	sw.	11	5	3	22	7.9	12.2	10.0
Madison [2]	974	70	78	29.02	30.10	+.04	33.7	−1.5	65	3	41	4	28	27	41	30	26	81	2.90	+1.1	12	10.2	nw.	40	sw.	11	4	11	15	7.2	14.9	12.5
Charles City	1,015	10	51	29.00	30.13	+.05	31.2	−1.8	68	3	39	1	15	23	42	28	25	83	3.62	+2.1	10	7.6	nw.	34	w.	11	8	3	19	6.8	7.0	4.3
Davenport [3]	606	66	161	29.46	30.14	+.06	37.2	−1.8	71	3	46	6	13	29	41	32	28	80	1.48	−.3	10	11.4	nw.	38	sw.	11	7	8	15	6.4	2.8	.7
Des Moines [3]	860	5	99	29.17	30.12	+.04	35.6	−2.8	72	3	44	3	13	27	43	31	27	77	2.17	+.7	8	11.0	nw.	36	nw.	11	9	6	15	6.4	2.0	T
Dubuque	699	60	77	29.35	30.12	+.05	34.8	−2.2	70	3	43	2	28	26	44	31	27	77	1.98	+.3	11	7.0	nw.	22	sw.	11	4	6	20	7.8	4.7	3.0
Keokuk	614	64	78	29.46	30.14	+.05	39.4	−1.7	73	3	48	5	13	31	40	32	28	75	1.70	−.2	10	8.9	nw.	41	w.	11	10	6	14	6.0	3.8	1.4
Cairo	358	87	93	29.79	30.18	+.06	47.2	−.1	77	3	56	16	15	39	31	.....	.....	.....	4.09	+.4	10	9.1	s.	37	sw.	11	10	5	15	6.0	.0	.0
Peoria [2]	609	11	45	29.46	30.14	+.05	38.2	+.7	74	3	48	8	13	29	30	33	29	80	1.89	−.5	9	7.6	w.	29	sw.	11	11	6	13	5.4	1.3	T
Springfield, Ill. [3]	636	5	191	29.45	30.16	+.06	41.1	−1.1	76	3	50	11	15	33	35	34	30	79	2.46	−.1	9	12.3	s.	46	sw.	11	9	5	16	6.1	T	.0
St. Louis [3]	568	179	303	29.54	30.16	+.06	44.2	−1.2	77	3	52	13	15	36	32	38	31	65	3.23	+.4	9	12.5	w.	38	sw.	11	8	12	10	5.4	T	.0
Missouri Valley							36.4	−3.2										78	2.33	+0.9										6.3		
Columbia, Mo. [2]	784	6	66	29.30	30.16	+.07	41.4	−1.9	75	3	51	6	15	32	37	35	30	73	2.49	+.2	9	8.4	s.	30	sw.	11	9	10	11	6.0	1.0	.0
Kansas City [1]	963	38	45	29.09	30.15	+.06	40.8	−2.9	77	2	50	8	15	31	38	36	30	71	3.95	+2.1	11	11.5	sw.	34	w.	11	9	8	13	6.0	2.6	.0
St. Joseph [2]	967	11	76	29.09	30.15	......	39.2	−2.3	73	2	48	5	14	30	37	34	31	82	2.53	+1.0	11	9.8	nw.	38	nw.	11	9	8	13	5.9	3.2	.0
Springfield, Mo. [1]	1,324	5	78	28.72	30.16	+.06	43.0	−2.7	74	2	53	6	15	33	37	37	33	78	3.07	+.3	11	11.8	se.	43	sw.	11	12	6	12	5.4	.5	.0
Topeka	987	65	87	29.07	30.15	......	40.1	−2.7	77	2	50	6	14	31	33	35	31	74	3.34	+1.8	12	9.8	s.	29	nw.	11	8	10	12	6.4	1.0	.0
Lincoln [2]	1,189	11	81	28.84	30.15	+.07	35.4	−3.7	71	3	44	0	14	27	29	30	27	81	2.12	+1.0	9	10.0	s.	39	nw.	11	8	6	16	6.8	5.2	.0
Omaha [1]	1,105	31	44	28.93	30.15	+.07	34.8	−3.7	71	3	43	−3	14	26	33	30	27	78	2.24	+1.2	8	10.3	nw.	36	w.	11	7	4	19	7.0	2.0	.0
Valentine	2,598	46	54	27.34	30.15	+.07	30.4	−4.2	68	3	41	−16	14	20	38	26	22	78	1.09	+.5	7	8.7	w.	29	nw.	11	10	6	14	5.9	9.0	T
Sioux City [2]	1,138	64	106	28.89	30.15	+.07	31.0	−4.2	64	1	39	−6	14	23	35	27	.....	83	1.74	+.7	8	9.9	nw.	43	nw.	11	5	6	19	7.2	7.6	.8
Huron [1]	1,306	26	41	28.71	30.15	+.07	27.8	−3.7	60	2	37	−14	14	19	33	25	21	79	.70	+.1	8	14.2	nw.	46	n.	11	7	10	13	6.6	7.6	2.9
Northern Slope							27.4	−5.4										77	0.83	+0.1										6.2		
Billings	3,570	18	39	26.38	30.16	......	29.0	......	58	2	37	−6	12	20	28	26	21	75	.71	......	8	11.3	sw.	40	sw.	28	8	8	14	6.0	9.6	.0
Havre	2,507	11	67	27.47	30.22	+.19	21.3	−9.9	53	2	31	−15	12	11	39	19	16	80	.48	−.1	6	7.6	w.	26	sw.	15	9	5	16	6.2	8.4	1.4
Helena	4,124	85	111	25.88	30.26	+.16	23.0	−10.2	52	1	33	−13	12	13	31	20	16	77	.36	−.4	9	6.3	w.	34	sw.	29	4	9	17	7.0	8.3	.5
Missoula [2]	3,263	80	91	26.75	30.24	......	30.0	−3.5	53	1	37	7	13	23	26	26	24	86	1.04	−.2	10	5.1	se.	32	w.	7	4	10	16	6.9	5.0	T
Kalispell	2,973	48	56	27.06	30.24	+.17	25.3	−7.1	48	1	32	0	12	19	23	24	22	84	2.02	+.7	14	4.1	w.	18	n.	9	1	5	24	8.8	15.4	3.4
Miles City [3]	2,371	48	55	27.61	30.20	+.13	26.3	−4.6	57	2	36	−10	12	17	41	22	18	78	.34	−.2	5	5.8	s.	23	nw.	8	9	9	12	6.1	3.1	.9
Rapid City [3]	3,259	50	58	26.68	30.15	+.07	32.0	−3.9	66	15	43	−3	14	21	43	25	19	68	.21	−.3	3	7.7	n.	26	nw.	18	13	7	10	4.7	.4	.0
Cheyenne [1]	6,094	5	39	24.00	30.14	+.07	32.2	−2.6	62	17	43	−12	12	21	32	25	19	65	.73	+.2	8	12.3	nw.	51	nw.	28	8	9	13	5.9	7.6	T
Lander	5,352	60	68	24.68	30.19	+.09	24.2	−6.1	63	2	36	−8	23	12	34	21	17	78	1.69	+1.1	9	4.3	e.	30	w.	29	10	11	9	5.1	17.8	3.0
Sheridan [6]	3,790	10	47	26.17	30.20	......	25.8	......	66	2	38	−8	11	14	43	22	19	83	.80	+.2	7	4.4	nw.	19	nw.	9	8	6	16	6.4	5.9	.0
Yellowstone Park	6,241	12	46	23.92	30.26	+.15	25.2	−3.9	48	17	34	−9	12	16	30	22	18	74	1.06	+.3	11	7.6	s.	24	sw.	29	9	4	17	6.5	11.7	2.5
North Platte [4]	2,821	11	51	27.12	30.14	+.06	34.8	−1.8	74	3	47	−8	14	23	41	27	23	75	.45	.0	6	7.4	n.	27	n.	4	12	10	8	4.8	2.3	.0

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch, or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Middle Slope							39.8	−3.0										72	2.53	+1.6										5.0		
Denver [2]	5,292	106	113	24.76	30.11	+.05	37.8	−2.0	73	2	49	4	13	27	36	28	20	60	.74	+.2	5	6.8	s.	26	w.	4	15	7	8	4.6	7.7	0.0
Pueblo [1]	4,690	79	86	25.32	30.12	+.07	36.0	−3.4	72	2	51	−12	13	21	48	29	22	63	.90	+.5	6	7.3	w.	35	nw.	4	12	7	11	5.1	11.8	.0
Concordia	1,392	50	58	28.63	30.15	+.07	37.6	−3.8	74	3	46	0	14	29	31	33	30	81	2.65	+1.7	9	8.9	sw.	33	nw.	11	11	10	9	5.2	3.0	.0
Dodge City	2,509	10	86	27.46	30.11	+.04	40.8	−1.8	78	2	52	2	14	29	49	34	30	74	2.39	+1.7	7	11.3	s.	38	n.	10	13	7	10	5.0	2.5	.0
Wichita [2]	1,358	85	93	28.67	30.14	+.06	40.7	−4.1	75	2	50	4	13	32	34	36	32	77	3.82	+2.4	9	11.4	s.	35	n.	30	14	3	12	4.8	1.7	.0
Oklahoma City [2]	1,214	10	47	28.84	30.14	+.06	45.6	−3.2	75	1	55	12	13	36	35	40	35	75	4.66	+2.8	9	10.4	s.	29	sw.	28	12	5	13	5.4	T	.0
Chadron	3,439	5	44	26.51	30.14	------	34.2	------	70	2	46	−10	14	22	45	28	21	---	.28	------	3	------	sw.	----	------	---	11	11	8	---	3.5	.0
Southern Slope							50.1	−1.7										68	2.17	+1.1										5.2		
Abilene [2]	1,738	10	56	28.28	30.11	+.04	52.2	−1.3	78	10	63	19	14	42	39	44	39	72	3.26	+1.9	9	9.8	s.	29	s.	18	11	3	16	5.9	.0	.0
Amarillo [2]	3,676	10	49	26.32	30.10	+.05	44.1	−1.4	76	2	55	11	13	33	40	35	29	71	3.87	+3.0	7	9.7	s.	30	w.	10	13	10	7	4.2	T	.0
Del Rio	960	63	71	29.09	30.09	+.04	57.5	−2.5	78	1	67	29	15	48	35	51	46	70	.52	−.7	7	8.3	se.	26	nw.	24	10	6	14	5.9	.0	.0
Roswell	3,566	75	85	26.43	30.09	+.06	46.6	−1.5	78	4	60	13	13	33	45	38	30	61	1.02	+.2	5	7.3	s.	35	nw.	10	14	6	10	4.8	1.7	.0
Southern Plateau							47.5	−0.9										56	0.74	+0.1										4.1		
El Paso [2]	3,778	82	101	26.24	30.05	+.05	50.8	−1.9	79	2	62	26	14	40	39	41	32	58	1.25	+.8	6	7.1	e.	28	nw.	10	13	11	6	4.5	.0	.0
Albuquerque [1]	4,972	5	34	25.10	30.06	------	41.4	−1.9	69	2	54	13	13	29	37	34	25	58	1.45	+1.0	6	7.9	se.	50	e.	23	11	6	13	5.1	9.3	.0
Santa Fe	7,013	38	53	23.27	30.12	+.09	37.8	−1.1	67	2	48	13	14	28	33	30	24	67	1.45	+.8	5	5.6	e.	23	nw.	4	10	7	13	5.7	7.5	.0
Flagstaff	6,907	10	59	23.35	30.01	−.01	36.4	+1.7	65	29	50	7	20	23	44	30	23	62	.92	−.5	6	8.6	nw.	29	n.	23	11	14	5	4.1	6.5	T
Phoenix [2]	1,107	39	51	28.84	30.00	+.02	58.9	−.8	86	2	73	36	26	45	40	47	37	55	.11	−.6	3	5.1	e.	19	w.	9	14	9	7	4.2	.0	.0
Yuma	142	9	54	29.87	30.02	+.04	61.0	−1.4	86	2	74	38	24	48	34	48	32	37	T	−.3	0	6.1	n.	24	w.	9	20	6	4	2.8	.0	.0
Independence	3,957	5	26	26.05	30.13	+.08	46.5	−.7	74	2	61	22	24	32	39	34	16	---	.01	−.3	1	5.5	nw.	----	------	---	---	---	---	2.5	.0	---
Middle Plateau							37.4	−2.0										70	1.09	+0.3										5.7		
Reno [2]	4,517	61	76	25.57	30.18	+.07	40.0	−1.5	67	29	51	19	23	29	36	33	26	66	.77	+.1	4	5.5	w.	27	sw.	1	10	15	5	5.1	.5	.0
Tonopah	6,090	12	20	24.11	30.15		37.8		61	15	47	16	23	29	24	30	20		.12		2		nw.								T	.0
Winnemucca	4,339		56	25.72	30.19	+.05	36.3	−2.1	61	29	48	14	23	25	40	32	27	70	.90	+.2	7	6.9	ne.	26	w.	1	7	5	18	6.6	1.0	.0
Modena	5,473	10	46				35.0	−1.4	63	29	48	10	24	21	41				.25	−.3	2	9.0	nw.	29	nw.	9	11	11	8	5.4	2.9	.0
Salt Lake City [2]	4,357	86	210	25.71	30.19	+.07	37.6	−3.5	65	1	46	13	23	29	25	32	28	78	2.70	+1.4	9	5.6	nw.	29	nw.	12	8	9	13	6.0	18.2	.0
Grand Junction	4,602	60	68	25.46	30.10	+.02	38.0	−1.3	63	3	48	17	13	28	29	32	26	65	.83	+.3	7	5.2	se.	29	w.	9	10	9	11	5.3	3.8	.0
Northern Plateau							34.1	−5.0										83	1.49	0.0										7.0		
Baker [2]	3,471	36	54	26.56	30.24	+.08	32.0	−4.0	52	7	40	10	13	24	27	28	26	87	.93	−.3	12	5.5	s.	20	s.	7	4	7	19	7.2	5.6	T
Boise [1]	2,739	5	49	27.20	30.23	+.05	35.5	------	59	7	43	15	22	28	22	34	31	86	1.32	------	14	8.6	se.	35	se.	5	9	2	19	6.8	4.7	.0
Pocatello	4,477	5	31	25.57	30.21	+.07	32.4	------	58	2	41	5	24	24	35	29	26	79	.71	------	7	8.3	sw.	34	s.	2	8	3	19	6.6	2.0	.0
Spokane	1,929	101	110	28.11	30.21	+.11	32.2	−6.3	52	1	38	9	12	27	21	31	29	87	2.37	−.3	12	5.1	ne.	19	s.	7	4	7	19	7.4	7.9	.6
Walla Walla	991	57	65	29.12	30.22	+.09	37.2	−5.6	60	7	43	18	12	32	22	----	----	---	1.81	−.2	13	4.7	s.	21	se.	7	6	3	21	7.4	4.6	.0
Yakima	1,076	58	67	29.03	30.22	------	34.9	−4.0	55	2	42	20	22	28	26	33	29	78	.86	.0	14	3.6	se.	19	sw.	7	8	3	19	6.8	1.7	.0
North Pacific Coast Region							45.0	−0.8										83	4.49	−1.9										8.0		
North Head	211	5	56	29.87	30.10	+.05	47.1	−1.1	58	14	52	37	10	42	14	44	41	80	7.12	−1.3	20	13.6	e.	53	sw.	7	2	8	20	7.5	.0	.0
Seattle [2]	125	90	321	29.99	30.13	+.09	44.6	−1.0	58	6	50	30	12	40	19	41	38	82	3.06	−2.0	14	8.0	se.	37	sw.	7	4	5	21	7.8	T	.0
Tacoma	194	172	201	29.92	30.13	+.09	43.2	−1.4	57	6	49	27	12	38	18	----	----	---	4.28	−2.0	17	6.5	sw.	31	sw.	7	0	10	20	8.3	T	.0
Tatoosh Island	86	9	61	29.99	30.09	+.12	46.0	+.1	54	7	49	35	10	43	12	43	40	80	6.70	−5.2	21	17.0	e.	62	sw.	7	5	8	17	7.2	T	.0
Medford [1]	1,329	29	58	28.75	30.20	------	43.2	−.6	61	14	51	22	22	35	30	41	39	84	2.23	−.2	17	------	n.	----	------	---	3	5	22	8.1	T	.0
Portland, Oreg. [2]	154	68	106	29.98	30.15	+.05	44.2	−2.6	61	6	50	30	22	39	22	41	39	86	4.82	−1.3	14	5.7	e.	25	e.	13	3	4	23	8.2	.0	.0
Roseburg	510	45	76	29.61	30.17	+.05	47.0	+1.1	62	28	53	29	22	41	26	45	42	86	3.24	−1.4	19	3.6	nw.	18	sw.	20	1	6	23	8.8	.0	.0
Middle Pacific Coast Region							53.6	−0.2										69	1.87	−1.6										6.3		
Eureka	60	72	88	30.10	30.17	+.06	51.2	+.1	66	14	58	34	22	44	20	48	46	83	2.29	−2.9	11	5.8	se.	29	se.	4	7	3	20	6.9	.0	.0
Redding [1]	722	20	34	29.35	30.13	------	53.7	−.4	76	15	62	34	21	45	30	45	36	56	1.65	−2.7	5	7.0	nw.	20	n.	26	7	6	17	7.0	.0	.0
Sacramento [2]	66	92	115	30.05	30.12	+.03	52.4	−1.2	72	14	62	34	23	43	28	46	41	69	1.32	−.6	4	6.1	n.	24	nw.	21	11	4	15	5.6	.0	.0
San Francisco	155	112	132	29.94	30.11	+.02	57.0	+.7	73	14	63	47	23	51	20	51	46	69	2.22	−.1	8	5.8	n.	22	w.	9	11	5	14	5.6	.0	.0
South Pacific Coast Region							58.8	+0.5										55	0.29	−0.7										4.8		
Fresno [1]	327	5	35	29.76	30.12	+.06	51.8	−2.4	73	17	65	30	23	39	34	46	39	64	.05	−.9	3	3.9	nw.	24	nw.	9	7	12	11	6.2	.0	.0
Los Angeles	338	223	250	29.67	30.03	+.01	63.4	+2.5	84	15	73	45	23	54	27	49	34	41	.34	−.9	2	7.3	ne.	33	nw.	9	15	8	7	4.0	.0	.0
San Diego [1]	87	62	70	29.93	30.02	.00	61.1	+1.4	89	15	72	41	23	51	36	52	44	60	.49	−.3	2	5.4	w.	1	7 e.		17	15	6	9	4.3 .0	.0
West Indies																																
San Juan, P. R.	82	10	54	29.83	29.92	------	79.2	+.8	89	7	84	71	15	75	14	----	----	---	4.42	−2.4	20	11.8	e.	34	ne.	12	3	19	8	6.0	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	------	[5] 29.81	−.01	80.0	+.9	91	23	87	71	26	73	18	----	----	[3] 89	5.35	−4.8	20	5.4	nw.	24	nw.	17	1	17	12	7.1	.0	.0
Cristobal	36	6	97	------	[5] 29.82	−.01	80.6	+1.3	89	30	85	71	14	76	14	76	75	[3] 86	20.91	−1.5	23	7.6	w.	26	nw.	14	0	5	25	8.5	.0	.0
Alaska																																
Fairbanks	454	11	87	------	------	------	6.4	−3.3	32	13	17	−20	23	−4	36	7	2	73	.54	−.2	7	5.0	e.	27	se.	13	9	5	16	5.9	6.7	6.4
Juneau	80	96	116	[4] 29.90	[4] 29.99	------	33.8	−1.6	49	13	38	20	5	30	15	31	23	65	6.75	------	14	9.1	ne.	38	ne.	7	5	5	20	7.6	5.1	T24
Nome	22	5	59	------	------	------	------	------	----	---	----	----	---	----	----	----	----	---	------	------	---	------	------	----	------	---	---	---	---	---	----	----
Hawaiian Islands																																
Honolulu	38	86	100	29.89	29.93	------	76.7	−2.2	85	25	81	69	21	72	13	70	67	73	5.35	+1.5	12	8.2	e.	31	e.	1	5	10	15	6.7	.0	.0

[1] Data are airport records.
[2] Barometric and hydrometric data from airport, other data from city office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to a mean of 24 hours.
[5] Barometric, hydrometric, and temperature records from airport, other data from city office records.
[6] Wind, and clear, partly cloudy, and cloudy data, from city office records, other data from airport records.

NOTE.—Except as indicated by notes 1, 2, 5, and 6, data in table are city office records.

SEVERE LOCAL STORMS

[Compiled by MARY O. SOUDER from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Washington, western portion of the State.	7				$6,000,000	Wind	Vibration from wind caused the destruction of the central span of the Narrows Bridge at Tacoma. The maximum wind velocity was recorded at 31 miles per hour.
South Dakota, eastern section.	9-12			2		Blizzard	High northwest winds, over 40 miles an hour, accompanied by drifting snows of blizzard proportion and zero visibility at times. Subzero temperatures snapped ice-coated communication lines, blocked highways, stalled railroad trains, caused cancelation of Armistice Day programs, closed schools, and marooned travelers. Stock, turkeys, chickens, and pheasants were frozen to death where shelter was lacking. 2 deaths due to severe weather.
Nebraska, south-central and southeastern portions.	10-11		[1] 100-200		200,000	Widespread ice-storm with freezing rain.	This storm was preceded by freezing rain over the south-central and south eastern portions. Estimated loss to turkeys and other livestock was $200,000. Many fruit and shade trees injured by the severe freeze, which came while most of the leaves were still green. Many roads and highways closed especially in the northeastern portion of the State, but were soon open to traffic again.
Minnesota	10-12			49	1,500,000	Glaze, sleet, snow, wind, and cold wave.	The storm began with drizzling rain during the afternoon of the 10th and changed to glaze and sleet on the morning of the 11th when the temperature dropped to the freezing point. Several hours later precipitation was entirely in the form of snow which continued through the remainder of the 11th and throughout most of the 12th with strong northerly to westerly winds that drifted the snow badly. The cold wave that followed in the wake of the storm caused much suffering and was very destructive. Hundreds of automobiles were abandoned in deep snow drifts, transportation facilities were at a standstill, and many persons unable to reach their homes. Train, bus, airplane, and street car service interrupted from the afternoon of the 11th to the afternoon of the 14th, and some services were not fully restored until the 16th. There were many miles of snow-drifts. In the Willmar area, drifts as high as 20 feet were reported. Highway traffic was blocked generally throughout the area affected. This condition improved very slowly. Some side roads were not open to traffic until near the close of November. Most seriously affected by the storm were the turkey farms, overhead wire systems, and the State highway department. Turkey losses were estimated at $500,000. Thousands of game birds as well as much livestock and poultry perished. The total loss from the storm and cold wave is estimated at over $1,500,000, but the economic loss from delayed traffic of all kinds, loss of wages and loss to business was much greater. Schools were closed for several days. Numerous accidents resulted from poor visibility. Many of the 49 persons who lost their lives were duck hunters, who, like others, were caught unprepared by the sudden storm and cold wave. Undoubtedly this storm will go down into meteorological history as the most severe ever experienced during November in the State.
Huntsville, Tex	11	1:10 a. m.	440		50,000	Straight-line-wind.	Damage to buildings, household goods, trees and livestock; public utility service disrupted.
Leota to Hollandale, Miss., and vicinities.	11	About 2 a.m.	50	0	200,000	Tornado	Property damaged; 7 persons injured.
Crocket Mills and Dresden, Tenn.	11	4:15-5 a. m.		0	160,000	do	Property damaged; several persons slightly injured.
Illinois, entire State	11			13	2,000,000	Wind	Widespread property damage with $1,500,000, at Chicago alone. From 75 to 100 persons injured. The highest wind velocity, 46 miles per hour, at Springfield, was the highest ever recorded for November at that place.
Indiana, entire State	11			1	200,000	do	This storm recorded as one of the most general and severe wind storms on record. Buildings, trees, poles, and wires damaged. 27 persons injured.
Davenport, Iowa, 1 mile west	11			0	3,000	Tornado	Storm moved northeastward and caused property damage along a 7-miles path.
Iowa, western and northern portions.	11				500,000	Blizzard	The heaviest snowfall, amounting to 17 inches, was recorded at Pringhar. High winds blew steadily in excess of 30 miles an hour for considerable period of time with some gusts exceeding 50 miles an hour, causing snow to drift badly interfering with rail and highway traffic. There was considerable damage to power and communication lines. Many highways blocked with considerable loss to motorists generally as well as to commercial truck operators. Thousands of private automobiles had frozen radiators. There were several automobile accidents caused by the storm and numerous cars were stalled in drifts. Buses ran behind schedule. Rail travel delayed, some trains canceled.
Michigan	11-12			73		Wind	With the exception of the storm of November 9-10, 1913, this was the most disastrous and widespread wind storm in the history of Michigan or Lake Michigan. The larger ships with loss of life are the Novadoc with a loss of 2 lives; the Minch, loss of 24 lives; the Davock, a 7,200 ton freighter, loss of 33 lives. The Novadoc, grounded near Pentwater and the remaining crew of 17 was safely removed by the fishing tug Three Brothers under command of Mr. Clyde Cross. The rescue was pointed out as an unusually heroic effort on the part of Mr. Cross and his assistants. Other heroic rescues were made by both fishermen and Coast Guard. Inland property damage including buildings, communication and power lines, trees and signboards. Automobiles had to slow down in order to keep from being blown from highways. Deer hunters headed from the Upper Peninsula were stranded at the Straits until the storm subsided. The wind of such terrific force from the southwest that it blew sufficient water out of the Saginaw River and the Saginaw Bay to cause the lowest reading of record at the official river gage at Saginaw. The depth of the water in the river was reduced by 8 feet during the blow and reports point out that the water line receded as much as a mile in Saginaw Bay. Extreme wind velocities ranged from 36 miles at Sault Ste Marie, Mich., to 80 miles at Grand Rapids and 56 miles at Detroit. Total damage estimated in millions of dollars.
New York, western and central portion of the State.	11-12			1	10,000	do	Wind reached gale force with considerable damage locally mostly to telegraphic and power lines, caused by falling trees and branches. Minor damage to windows and signs. Damage in Buffalo and vicinity estimated at $10,000. 2 girls seriously injured by falling tree.
Wisconsin, entire State except the far northeast.	11-12			23	300,000	do	Maximum wind velocity of 54 miles per hour from the southwest was recorded 4 separate times in Milwaukee. There was much suffering among duck hunters, many losing their lives through being marooned on islands because of high winds and waves on inland waters and subsequent exposure and freezing as the temperature dropped rapidly. 2 died in Waukesha County and it is estimated that about 20 were lost on the Mississippi River between St. Paul and Prairie du Chien, Wis. A man was killed by a falling wall in Milwaukee. Much damage to utility wires.
Union to Curry Counties, N. Mex.	23-24	2 days				Heavy snow and glaze.	Considerable damage to overhead lines in the extreme eastern portion of the State. No estimate of damage available.
Illinois, northern half of State.	26				10,000	Sleet and ice	Moderate damage to trees, telephone and power lines. Damage in De Witt County alone $10,000.
Ouachita County, Ark	27-28				1,000	Heavy rain and flood.	Loss in mature crops, $500; for suspension of business, $500.

[1] Miles instead of yards.

SOLAR RADIATION AND SUNSPOT DATA FOR NOVEMBER 1940

SOLAR RADIATION OBSERVATIONS

By Helen Cullinane

Measurements of solar radiant energy received at the surface of the earth are made at 9 stations maintained by the Weather Bureau and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at two Weather Bureau stations (Madison, Wis.; Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau station at Madison and at Blue Hill Observatory.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained, up to the end of 1936, will be found in the Monthly Weather Review, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Lincoln the observations are made with the Marvin pyrheliometer; at Madison and Blue Hill they are obtained with a recording thermopile, checked by observations with a Smithsonian silver-disk pryheliometer at Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

The supervising station for the Solar Radiation Investigations of the Weather Bureau was moved on November 1, 1940, to the Harvard Blue Hill Meteorological Observatory at Milton, Mass., where it is thought mutual benefit will result through cooperation with the many other research workers in solar studies in and around Boston. Moreover, it is thought that the skies at Blue Hill will be somewhat better than those in the suburbs of Washington, D. C.

Some extension of the work of the Solar Radiation Investigations Section will occur, notably the addition of studies of certain component radiations, a careful check on all radiation apparatus in use by our own and cooperating stations, the addition of new equipment at Weather Bureau stations already established, and an attempt to improve existing apparatus. It also is expected that much closer cooperation will exist with other institutions and individuals engaged in similar work.

Difficulties at Twin Falls, Idaho, have been straightened out, and radiation data for several months at that station will be found later in this report.

Total solar and sky radiation was below normal at Washington, D. C., Twin Falls, and Blue Hill, while it was practically normal at all other stations.

There was only one polarization measurement at Madison, Wis., on November 25, giving a value of 62.7, compared with a mean for the month of 66 and a maximum of 69.

TABLE 1.—*Solar radiation intensities during November 1940*

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance										
	7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m.
	75th mer. time	Air mass									Local mean solar time
		A. M.				P. M.					
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
MADISON, WIS.											
November 13	1.37	0.84	1.06	1.16	------	1.56	------	1.13	------	------	1.52
November 15	1.37	.95	1.07	1.22	------	------	------	------	------	------	1.68
November 25	2.36	.76	.95	1.14	------	1.65	------	------	------	------	3.00
November 29	1.37	.87	1.02	1.21	------	1.65	------	------	------	------	2.26
Means	------	.86	1.02	1.18	------	1.62	------	(1.13)	------	------	------
Departures	------	−.02	+.02	+.02	------	+.05	------	+.01	------	------	------

* Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Newport	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	Cambridge	Friday Harbor	Ithaca	Albuquerque
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
October 29	205	189	------	------	156	322	214	58	178	363	268	306	338	202	201	123	------	368
November 5	208	125	127	------	176	299	180	40	156	310	319	230	314	146	157	125	------	352
November 12	148	235	260	------	70	251	97	16	222	233	368	308	226	71	64	122	------	401
November 19	178	122	91	------	145	237	164	14	145	296	321	200	285	154	146	94	------	179
November 26	166	109	138	------	136	223	170	21	146	301	298	238	284	173	166	56	------	295
DEPARTURES FROM WEEKLY NORMALS																		
October 29	−41	+2	------	------	−25	−20	+2	+17	−41	+39	−47	+9	+29	−21	------	−10	------	------
November 5	−18	−43	−115	------	+17	−6	+12	+3	−50	+14	−21	−56	+12	−53	------	+14	------	------
November 12	−48	+84	+48	------	−61	−4	−37	−12	+52	−59	+34	+77	−62	−76	------	+28	------	------
November 19	−7	−9	−111	------	+17	−6	+15	−4	−11	+12	−1	−48	+9	+6	------	−10	------	------
November 26	+2	−16	−46	------	+20	+12	+14	+7	−5	+27	+9	+12	+22	+10	------	−34	------	------
ACCUMULATED DEPARTURES ON DECEMBER 2, 1940																		
	+5,761	+5,887	------	------	+9,534	−714	−1,999	+5,236	------	−3,829	−2,702	+11,007	------	−5,670	------	------	------	------

LATE DATA

The following total solar and sky radiation figures represent late data for the stations at Blue Hill, Massachusetts; Fairbanks, Alaska; and Twin Falls, Idaho, for the periods shown.

Week of—	Blue Hill Observation	Blue Hill Departure	Fairbanks Observation	Fairbanks Departure	Twin Falls Observation	Twin Falls Departure
Feb. 24	------	------	------	------	211	−76
Mar. 4	------	------	------	------	406	+66
Mar. 11	------	------	------	------	397	+73
Mar. 18	------	------	------	------	526	+132
Mar. 25	------	------	------	------	239	−110
Apr. 1	------	------	------	------	356	−75
Apr. 8	------	------	------	------	564	+98
Apr. 15	------	------	------	------	518	+35
Apr. 22	------	------	------	------	560	+54
Apr. 29	------	------	------	------	631	+105
May 6	------	------	------	------	594	+3
May 13	------	------	------	------	668	+57
May 20	------	------	------	------	635	−10
May 27	------	------	------	------	621	+22
July 2	------	------	------	------	643	+45
July 9	------	------	------	------	719	+112
July 16	------	------	------	------	633	+17
July 23	------	------	------	------	634	+161
July 30	------	------	------	------	673	+115
Aug. 6	------	------	------	------	599	+42
Aug. 13	------	------	------	------	610	+100
Aug. 20	------	------	------	------	493	−30
Aug. 27	------	------	------	------	447	−37
Sept. 3	------	------	------	------	353	−120
Sept. 10	------	------	------	------	383	−63
Sept. 17	------	------	------	------	387	−21
Sept. 24	------	------	------	------	333	−81
Oct. 1	278	−32	151	+33	359	−4
Oct. 8	313	−9	85	−7	380	+31
Oct. 15	272	[illegible]	85	+12	326	+1
Oct. 22	262	[illegible]	46	−13	154	−127
Accumulated departures on Oct. 28	−4,732	------	+5,159	------	------	------

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory.] All measurements and spot counts were made at the Naval Observatory from plates taken at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day, under longitude, latitude, area of spot or group, and spot count, are included assumed longitude of center of the disk, assumed latitude of center of the disk, total area of spots and groups, and total spot count.

Date	Eastern standard time h	Eastern standard time m	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	*h*	*m*		°	°	°	°				
Nov. 1	10	48	7022	−44	60	+14	45	267	12	G	U.S. Naval.
			7025	−37	67	−9	40	12	7		
			7023	−32	72	−9	34	24	1		
			7021	−3	101	+13	10	48	9		
			7019	+78	182	−3	78	97	3		
			7024	+80	184	−9	80	12	1		
					(104)	(+4)		460	33		
Nov. 2	10	37	7022	−31	60	+14	33	242	17	VG	Do.
			7025	−25	66	−9	28	73	8		
			7023	−16	75	−9	21	24	3		
			7021	+12	103	+14	16	24	5		
			7027	+44	135	+9	44	48	3		
			7026	+56	147	−8	57	24	2		
					(91)	(+4)		435	38		
Nov. 3	11	56	(*)	−75	2	−17	77	6	1	G	Do.
			(*)	−68	9	+15	68	48	2		
			7022	−17	60	+17	22	54	11		
			7022	−11	66	+14	15	121	5		
			7025	−11	66	−7	16	97	13		
			7023	0	77	−7	11	6	2		
			(*)	+60	137	+3	60	97	6		
			(*)	+70	147	−17	73	48	3		
					(77)	(+4)		477	43		
Nov. 4	10	45	7030	−57	7	+8	57	73	13	G	Do.
			7029	−49	15	−18	53	12	2		
			7022	−7	57	+16	13	12	1		
			7022	+1	65	+14	10	145	11		
			7025	+3	67	−7	11	73	11		
			7023	+15	79	−7	20	6	1		
			7028	+22	86	+8	22	12	1		
			7027	+70	134	+10	70	109	5		
					(64)	(+4)		442	45		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS—Continued

Date	Eastern standard time h	Eastern standard time m	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	*h*	*m*		°	°	°	°				
Nov. 5	11	8	7030	−45	6	+7	45	12	4	G	U. S. Naval.
			7030	−39	12	+9	39	73	9		
			7029	−36	15	−17	41	6	1		
			7031	−16	35	+10	18	12	1		
			7022	+8	59	+15	13	12	1		
			7022	+15	66	+14	19	121	12		
			7025	+20	71	−8	24	24	6		
			7023	+30	81	−9	33	24	2		
			7028	+40	91	+9	40	12	6		
					(51)	(+4)		296	42		
Nov. 6	13	4	7034	−83	314	−11	83	145	2	G	Do.
			7030	−31	6	+7	32	48	7		
			7030	−26	11	+9	27	97	12		
			7033	−22	15	+16	25	6	1		
			7031	− 2	35	+10	6	6	1		
			7032	+27	64	−1	27	48	4		
			7022	+29	66	+12	30	97	7		
			7025	+33	70	−8	35	24	4		
			7023	+44	81	−8	47	24	6		
					(37)	(+4)		495	44		
Nov. 7	11	59	7035	−77	307	+7	77	12	1	F	Do.
			7034	−70	314	−11	71	97	1		
			7030	−17	7	+7	18	73	18		
			7030	−11	13	+9	12	61	1		
			7032	+40	64	0	41	97	4		
			7022	+41	65	+13	42	73	4		
			7025	+47	71	−8	49	12	1		
			7023	+59	83	−8	60	36	1		
					(24)	(+4)		461	31		
Nov. 8	11	20	7038	−86	285	+9	86	48	1	VG	Mt. Wilson.
			7037	−82	289	+16	82	24	1		
			7035	−63	308	+7	63	36	5		
			7034	−57	314	−10	59	97	1		
			7036	−53	318	+7	53	12	4		
			7030	−3	8	+9	6	121	20		
			7030	+5	16	+9	5	48	2		
			7032	+54	65	0	54	73	5		
			7022	+55	66	+13	56	133	10		
			7023	+72	83	−8	72	24	1		
					(11)	(+4)		616	50		
Nov. 9	11	44	7038	−72	286	+8	72	48	1	G	U. S. Naval.
			7037	−68	290	+16	69	24	4		
			7035	−48	310	+7	48	48	10		
			7034	−44	314	−10	46	61	1		
			7036	−38	320	+7	38	242	15		
			(*)	+8	6	+10	11	12	1		
			7030	+10	8	+8	11	24	6		
			7030	+19	17	+8	20	24	3		
			7022	+69	67	+12	69	97	7		
					(358)	(+3)		580	48		
Nov. 10	11	6	7040	−70	275	−8	70	6	1	G	Mt. Wilson.
			7038	−59	286	+10	59	73	3		
			7037	−52	293	+17	53	6	2		
			7035	−33	312	+7	33	97	10		
			7034	−30	315	−11	33	61	1		
			7036	−24	321	+7	24	436	16		
			7039	−4	341	−15	19	24	3		
			7030	+32	17	+8	32	36	2		
			(*)	+33	18	−17	39	24	3		
			7022	+80	65	+11	80	24	1		
					(345)	(+3)		787	42		
Nov. 11	11	2	7044	−78	254	−17	79	48	1	G	U. S. Naval.
			7038	−45	287	+9	45	48	3		
			7035	−20	312	+7	21	73	9		
			7034	−17	315	−11	22	61	1		
			7043	−12	320	−11	19	12	6		
			7036	−11	321	+7	12	364	23		
			7042	+21	353	+18	26	6	1		
			7030	+45	17	+9	45	24	1		
			7041	+66	38	+10	66	6	2		
					(332)	(+3)		642	47		
Nov. 12	12	14	7044	−65	253	−16	68	48	1	F	Mt. Wilson.
			7038	−32	286	+9	32	36	2		
			7046	−17	301	−12	22	48	7		
			7035	−6	312	+8	8	73	12		
			7034	−2	316	−11	14	61	1		
			7043	+2	320	−11	14	6	1		
			7036	+4	322	+8	6	412	16		
			7042	+37	355	+17	40	6	1		
			7045	+44	2	+20	46	6	2		
			7030	+61	19	+9	61	12	1		
					(318)	(+3)		706	44		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS—Con.

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°				
Nov. 13	12 20	7049	−74	231	−11	75	48	1	G	Mt. Wilson.
		7044	−52	253	−16	56	48	1		
		7048	−39	266	−12	41	12	1		
		7038	−19	286	+9	20	12	1		
		7046	−4	301	−10	13	48	9		
		7047	−4	301	+17	15	194	22		
		7035	+7	312	+8	10	73	16		
		7034	+11	316	−11	18	61	1		
		7036	+17	322	+8	18	388	20		
		7045	+59	4	+19	60	12	2		
				(305)	(+3)		896	74		
Nov. 14	13 7	7049	−59	232	−10	61	48	1	P	Do.
		7044	−38	253	−17	42	48	1		
		7048	−24	267	−13	30	121	14		
		7047	+10	301	+17	16	194	21		
		7035	+20	311	+8	21	12	5		
		7034	+25	316	−10	28	48	1		
		7035	+27	318	+8	28	24	6		
		7036	+32	323	+8	32	242	12		
				(291)	(+3)		737	61		
Nov. 15	12 4	7051	−73	206	−12	74	12	1	G	U. S. Naval.
		7049	−47	232	−11	49	73	1		
		7044	−24	255	−17	31	48	1		
		7048	−9	270	−13	19	485	12		
		(*)	−2	277	−7	10	12	1		
		7047	+22	301	+18	26	388	17		
		7046	+22	301	−12	27	6	1		
		7034	+38	317	−11	40	48	1		
		7035	+41	320	+8	41	48	6		
		7036	+48	327	+8	48	194	1		
		7050	+82	1	+10	82	48	1		
				(279)	(+3)		1, 362	43		
Nov. 16	10 38	7053	−75	191	−12	77	48	1	VG	Do.
		7051	−60	206	−12	63	24	1		
		7049	−33	233	−12	36	73	1		
		7044	−11	255	−17	22	48	1		
		7048	+3	269	−13	16	485	21		
		7052	+11	277	−7	15	12	2		
		7047	+32	298	+17	34	170	5		
		7047	+39	305	+18	40	291	1		
		7034	+51	317	−11	54	61	4		
		7036	+61	327	+9	61	194	1		
				(266)	(+3)		1, 406	38		
Nov. 17	12 4	7057	−76	176	−12	78	61	1	G	Do.
		7053	−61	191	−12	64	73	1		
		7051	−45	207	−12	48	73	1		
		7056	−20	232	−19	30	12	2		
		7049	−19	233	−11	24	73	2		
		7055	−11	241	+22	21	6	1		
		7054	−5	247	−15	19	6	2		
		7044	+2	254	−17	20	24	1		
		7048	+18	270	−13	25	485	16		
		7052	+24	276	−7	26	12	1		
		7047	+45	297	+18	46	145	4		
		7047	+53	305	+18	55	291	1		
		7034	+64	316	−11	66	24	1		
		7036	+76	328	+9	76	194	1		
				(252)	(+3)		1, 479	35		
Nov. 18	15 36	7057	−68	169	−12	69	24	1	VG	Do.
		7057	−60	177	−12	60	109	1		
		7053	−47	190	−12	49	73	1		
		7051	−31	206	−12	33	24	3		
		7058	−8	229	+10	11	6	1		
		7049	−5	232	−11	13	73	4		
		7044	+15	252	−17	24	24	5		
		7048	+33	270	−13	36	436	15		
		7047	+59	296	+18	60	121	4		
		7047	+67	304	+18	69	291	1		
		7034	+80	317	−11	80	12	1		
				(237)	(+2)		1, 193	37		
Nov. 19	11 13	7057	−55	171	−12	56	12	1	G	Do.
		7057	−49	177	−11	50	109	1		
		7053	−35	191	−11	37	48	2		
		7049	+8	234	−12	16	24	2		
		7059	+21	247	+17	26	24	2		
		7048	+41	267	−12	43	24	4		
		7048	+49	275	−15	51	242	1		
		7047	+72	298	+18	74	97	1		
		7047	+80	306	+18	80	242	1		
				(226)	(+2)		822	15		
Nov. 20	11 38	7057	−40	173	−12	42	48	5	F	Do.
		7057	−36	177	−9	38	97	3		
		7053	−22	191	−11	26	6	1		
		7059	+34	247	+18	37	6	1		
		7048	+62	275	−15	65	242	2		
				(213)	(+2)		399	12		
Nov. 21	11 46	7057	−27	173	−12	30	73	5	G	Do.
		7057	−24	176	−11	27	48	3		
		7057	−20	180	−10	23	73	1		
		7048	+75	275	−16	77	194	2		
				(200)	(+2)		388	11		
Nov. 22	10 42	7057	−13	174	−11	18	48	6	G	U. S. Naval.
		7057	−11	176	−10	16	48	3		
		7057	−8	179	−11	16	73	1		
		(*)	−3	184	−8	10	24	1		
				(187)	(+2)		193	11		
Nov. 23	10 33	(*)	−70	104	+12	70	6	1	G	Do.
		7057	+3	177	−12	15	236	15		
				(174)	(+2)		242	16		
Nov. 24	11 35	7061	−53	107	+13	54	97	10	VG	Mt. Wilson.
		7057	+17	177	−11	21	242	30		
		7060	+27	187	−7	29	73	10		
				(160)	(+2)		412	50		
Nov. 25	13 12	7062	−77	69	+14	78	485	1	P	Do.
		7061	−38	108	+13	40	121	6		
		7057	+30	116	−11	32	194	10		
		7060	+41	187	−7	42	145	8		
				(146)	(+2)		945	25		
Nov. 26	13 49	7062	−62	71	+14	63	339	1	G	Do.
		7061	−25	108	+12	27	121	6		
		7057	+44	177	−12	47	194	8		
		7060	+54	187	−7	55	97	4		
				(133)	(+1)		751	19		
Nov. 27	10 29	7062	−50	71	+13	52	291	1	P	U. S. Naval.
		7061	−13	108	+11	16	97	6		
		7063	+19	140	+13	22	48	6		
		7064	+19	140	+11	21	24	2		
		7057	+58	179	−11	59	170	5		
				(121)	(+1)		630	20		
Nov. 28	10 48	7062	−38	70	+12	39	291	7	P	Do.
		7061	−1	107	+11	9	48	4		
		7064	+32	140	+9	33	24	7		
		7063	+33	141	+13	35	97	5		
		7057	+71	179	−12	72	48	4		
				(108)	(+1)		508	27		
Nov. 29	10 57	7062	−24	71	+12	26	291	5	G	Do.
		7061	+12	107	+11	15	48	3		
		7063	+47	142	+13	48	218	6		
		7064	+48	143	+9	49	48	5		
				(95)	(+1)		605	19		
Nov. 30	10 16	7062	−10	72	+12	15	242	4	F	Do.
		7063	+60	142	+13	60	242	6		
		7064	+60	142	+11	60	48	1		
				(82)	(+1)		532	11		

Mean daily area for 30 days=663

*=Not numbered.
VG=very good; G=good; F=fair; P=poor.

PROVISIONAL RELATIVE SUNSPOT NUMBERS FOR OCTOBER 1940

[Dependent on observations at Zurich except as otherwise noted. Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich.]

October 1940	Relative numbers	October 1940	Relative numbers	October 1940	Relative numbers
1	38	11	* 52	21	*b* 64
2		12	*abd* 77	22	*Ec* 74
3	29	13	*b* 72	23	68
4	32	14	66	24	(*a*)
5	*a* 35	15	*d* 70	25	
6	*Mcdd* 44	16	* *a* 62	26	* *Mc* 46
7		17	59	27	* *a* 41
8		18		28	* 48
9	53	19	61	29	* 40
10	*d* 57	20	67	30	*46
				31	38

Mean, 25 days=53.6

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c= New formation of a group developing into a middle-sized or large center of activity: *E*, on the eastern part of the sun's disk; *W*, on the western part; *M*, in the central-circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.
* Observed at Locarno.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, November 1940

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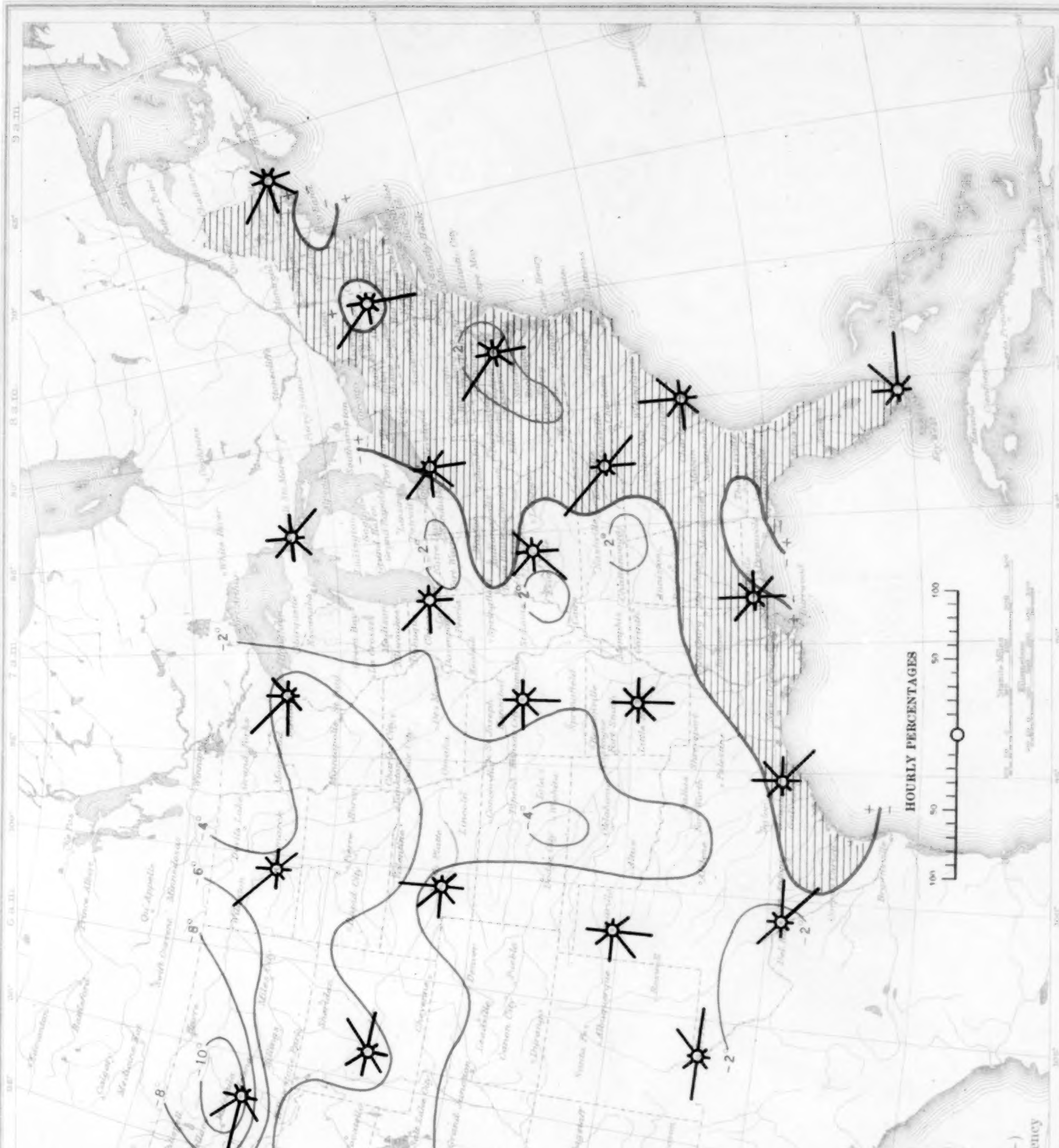
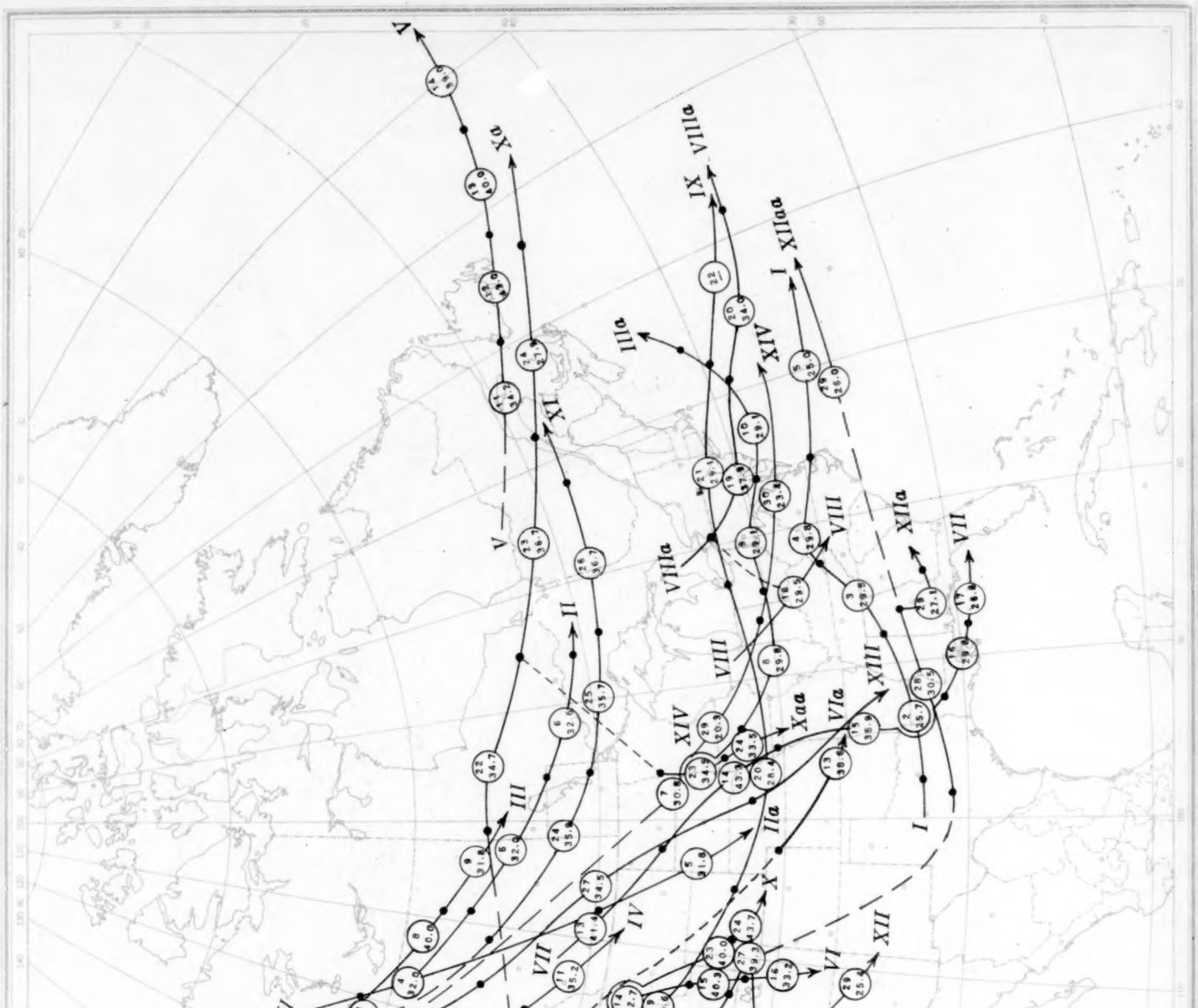


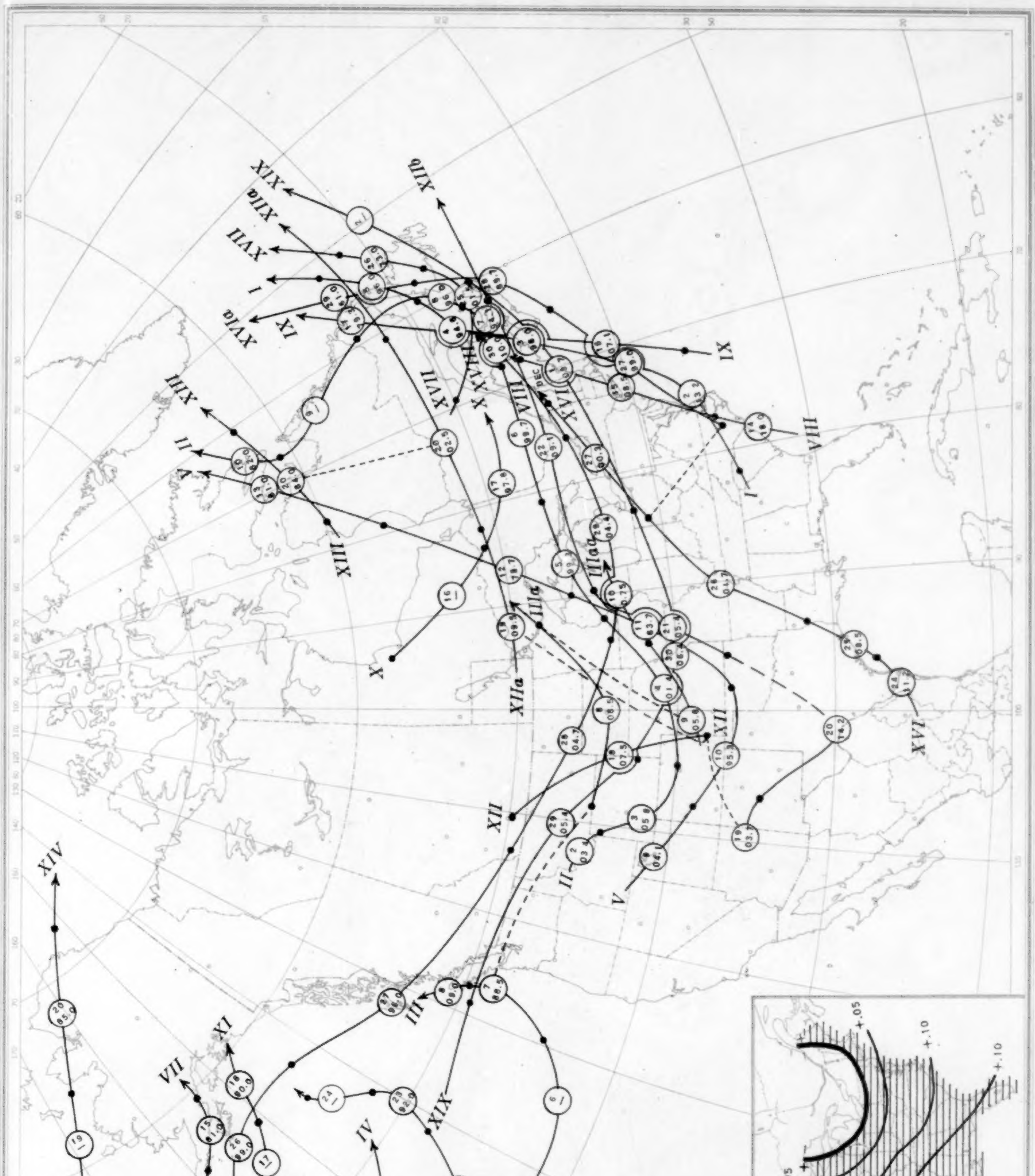
Chart II. Tracks of Centers of Anticyclones, November 1940. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, November 1940. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, November 1940. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, November 1940

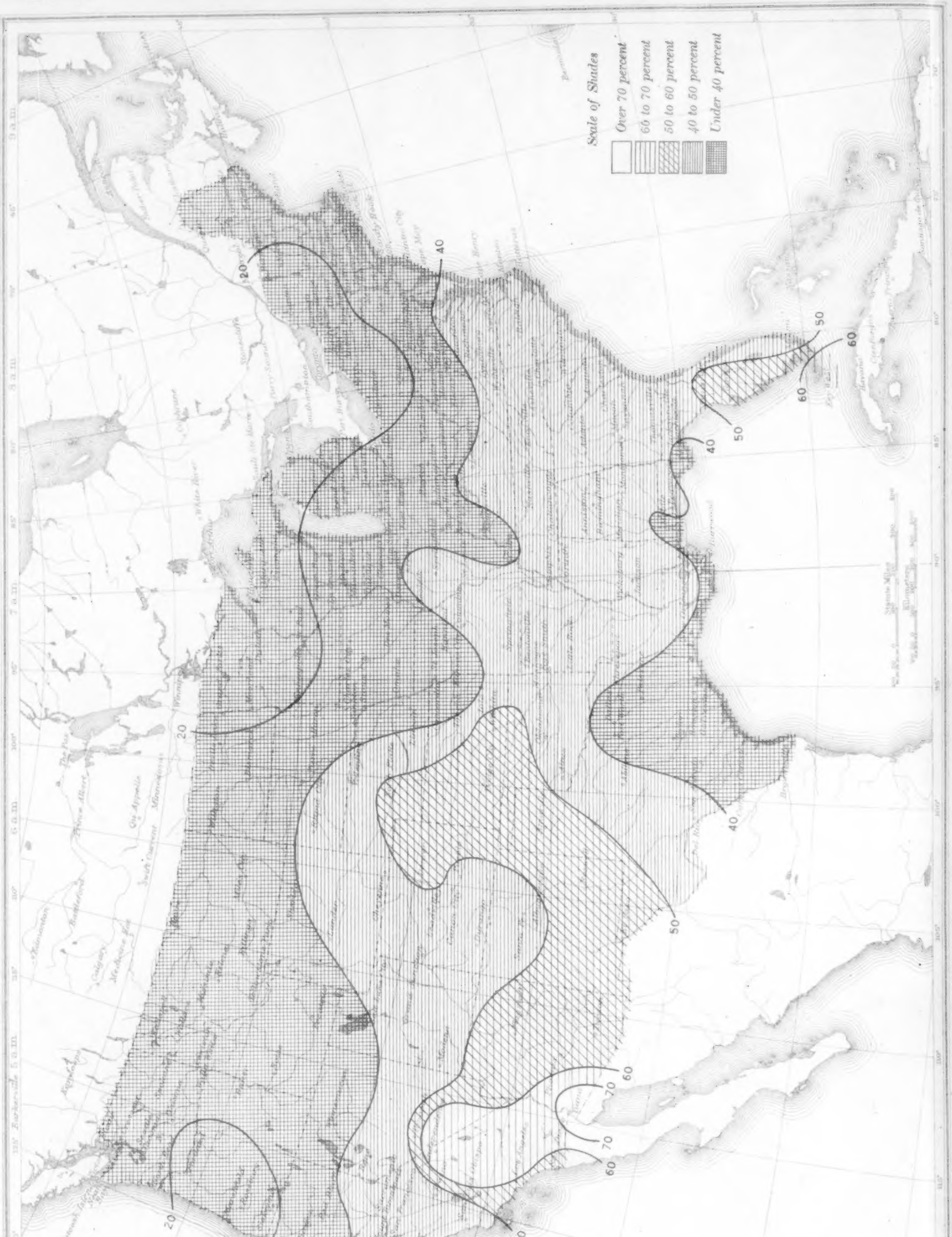
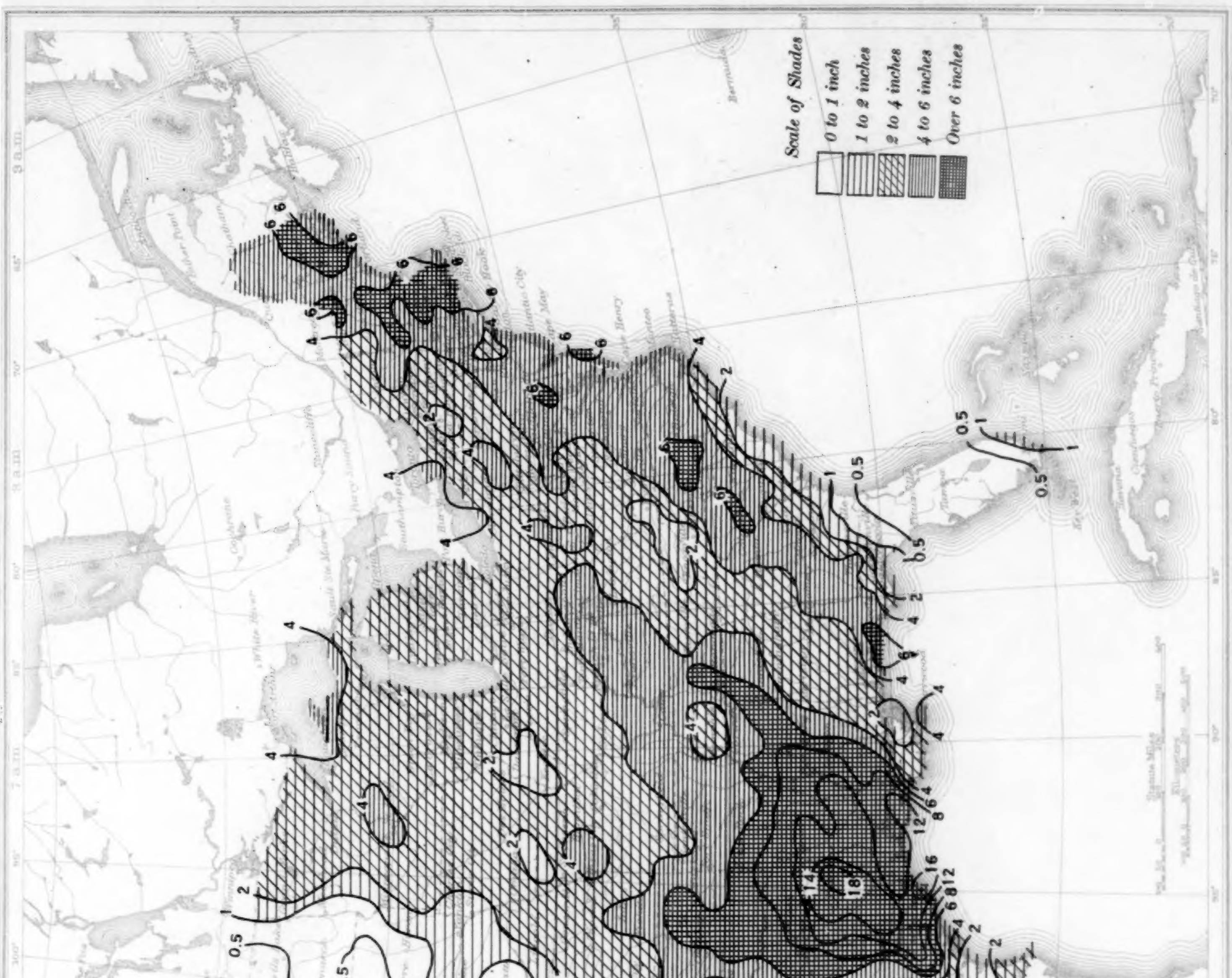


Chart V. Total Precipitation, Inches, November 1940. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, November 1940. (Inset) Departure of Precipitation from Normal



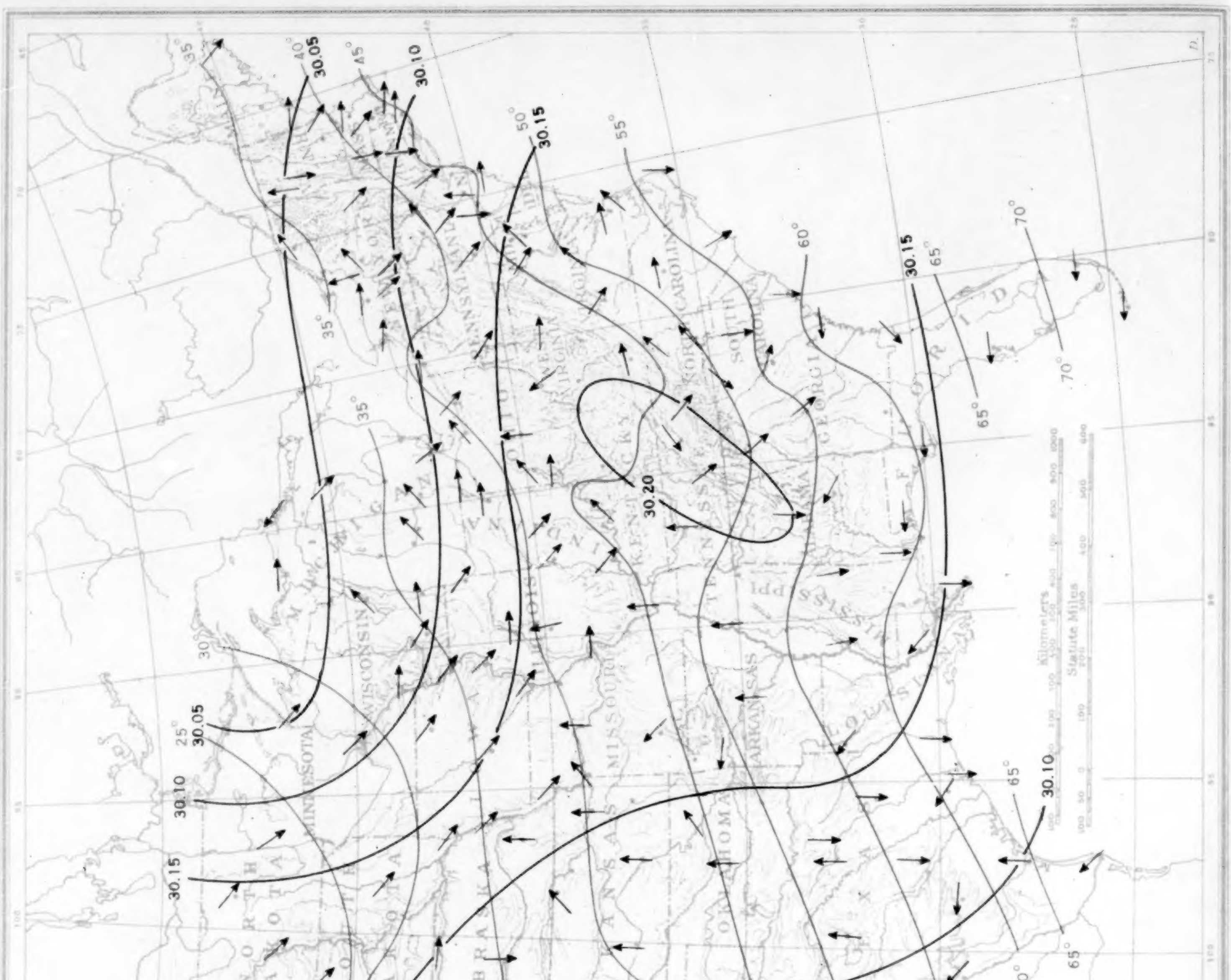


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, November 1940

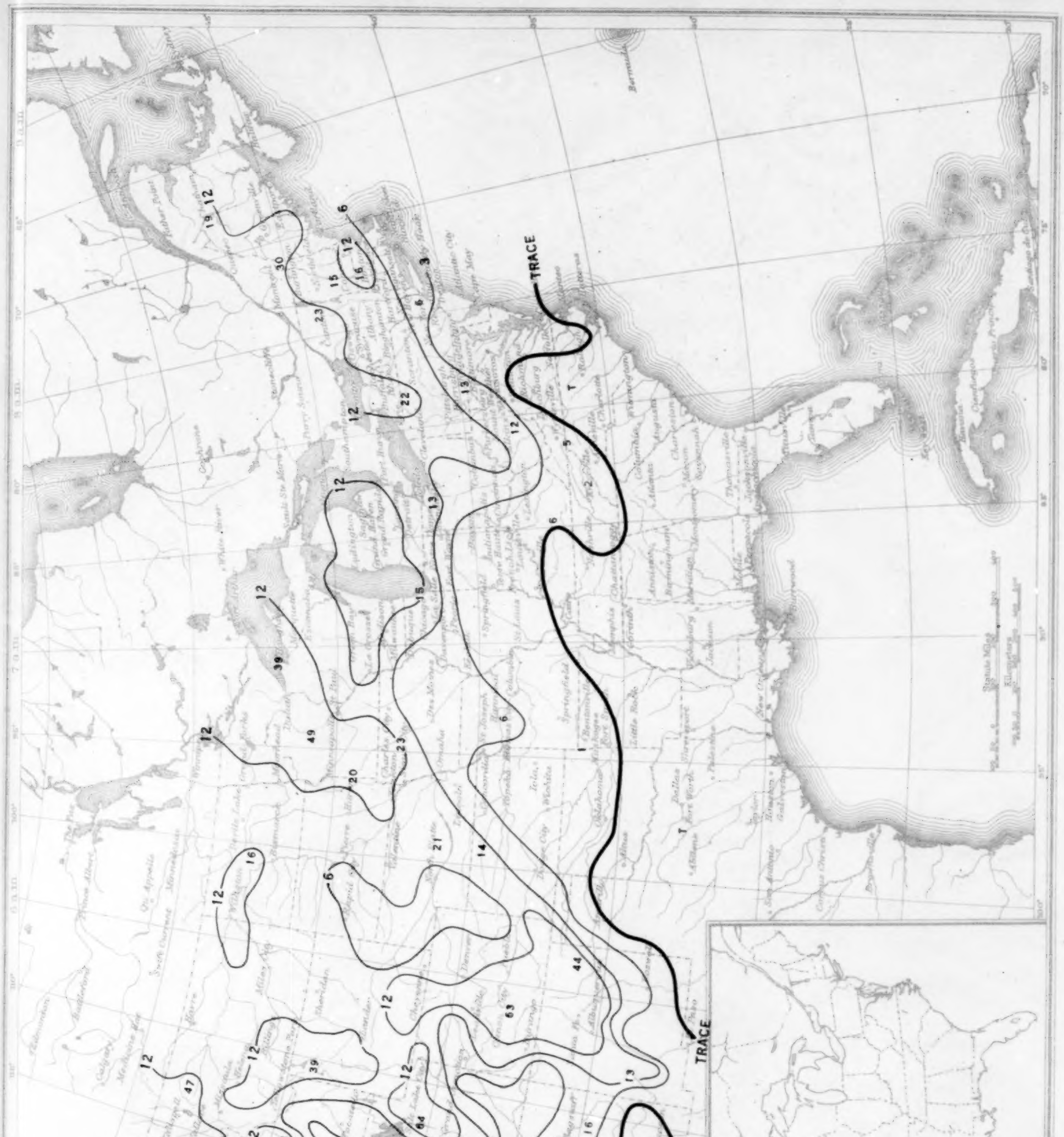

TRACE

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) November 1940

Isobars and isotherms based on radiosonde observations at 1:00 a. m. (E. S. T.) and winds based on pilot-balloon observations at 5:00 a. m. (E. S. T.).

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) November 1940

Isobars and isotherms based on radiosonde observations at 1:00 a. m. (E. S. T.) and winds based on pilot-balloon observations at 5:00 a. m. (E. S. T.).

Chart IX. Isobars (mb) Isotherms (°C.) 1:00 a. m. (E. S. T) and Resultant Winds 5:00 a. m. (E. S. T.) for 3,000 Meters (m. s. l.) November 1940

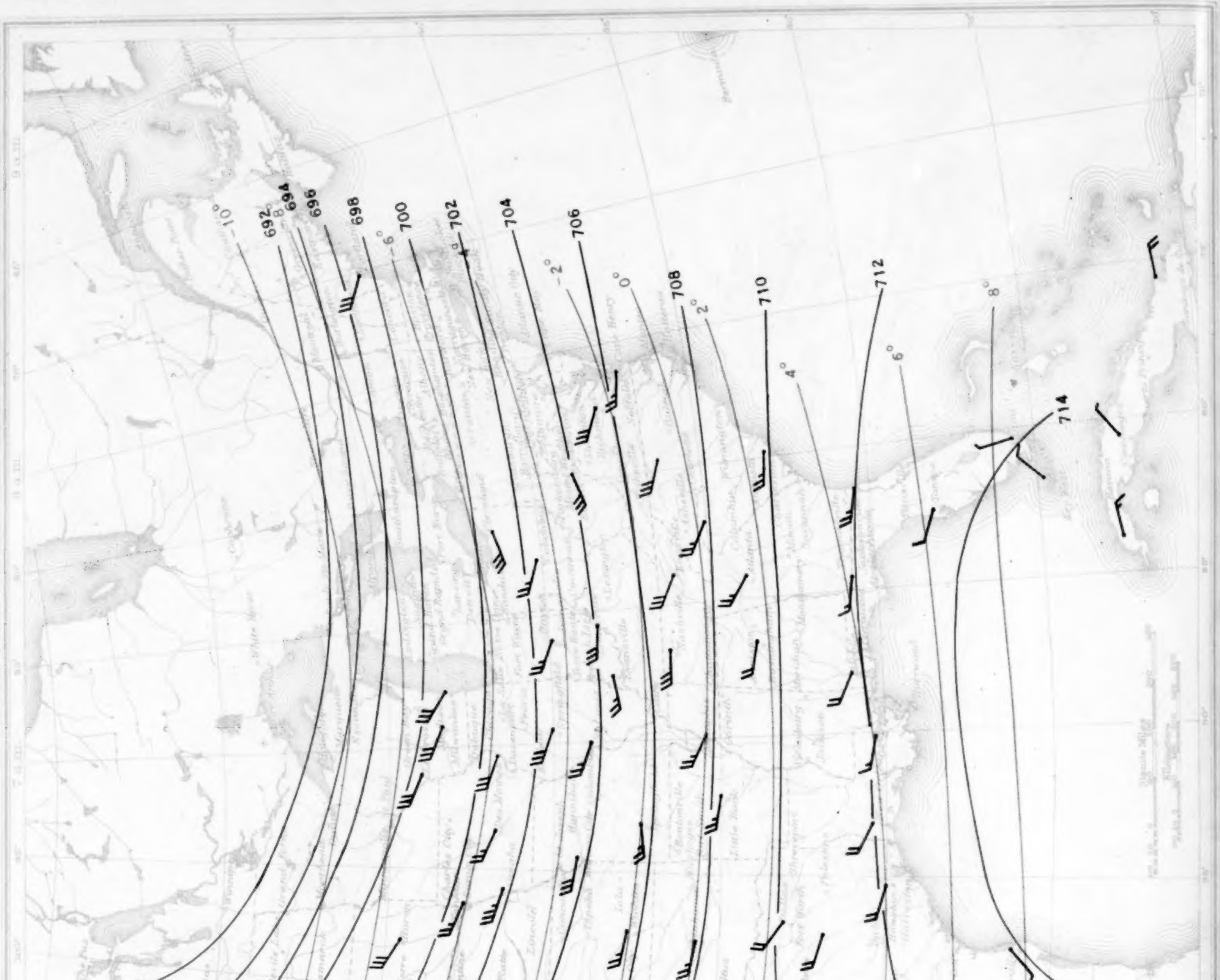


Chart X. Isobars (mb) Isotherms (°C.) 1:00 a. m. (E. S. T.) and Resultant Winds 5:00 p. m. (E. S. T.) for 5,000 Meters (m. s. l.) November 1940

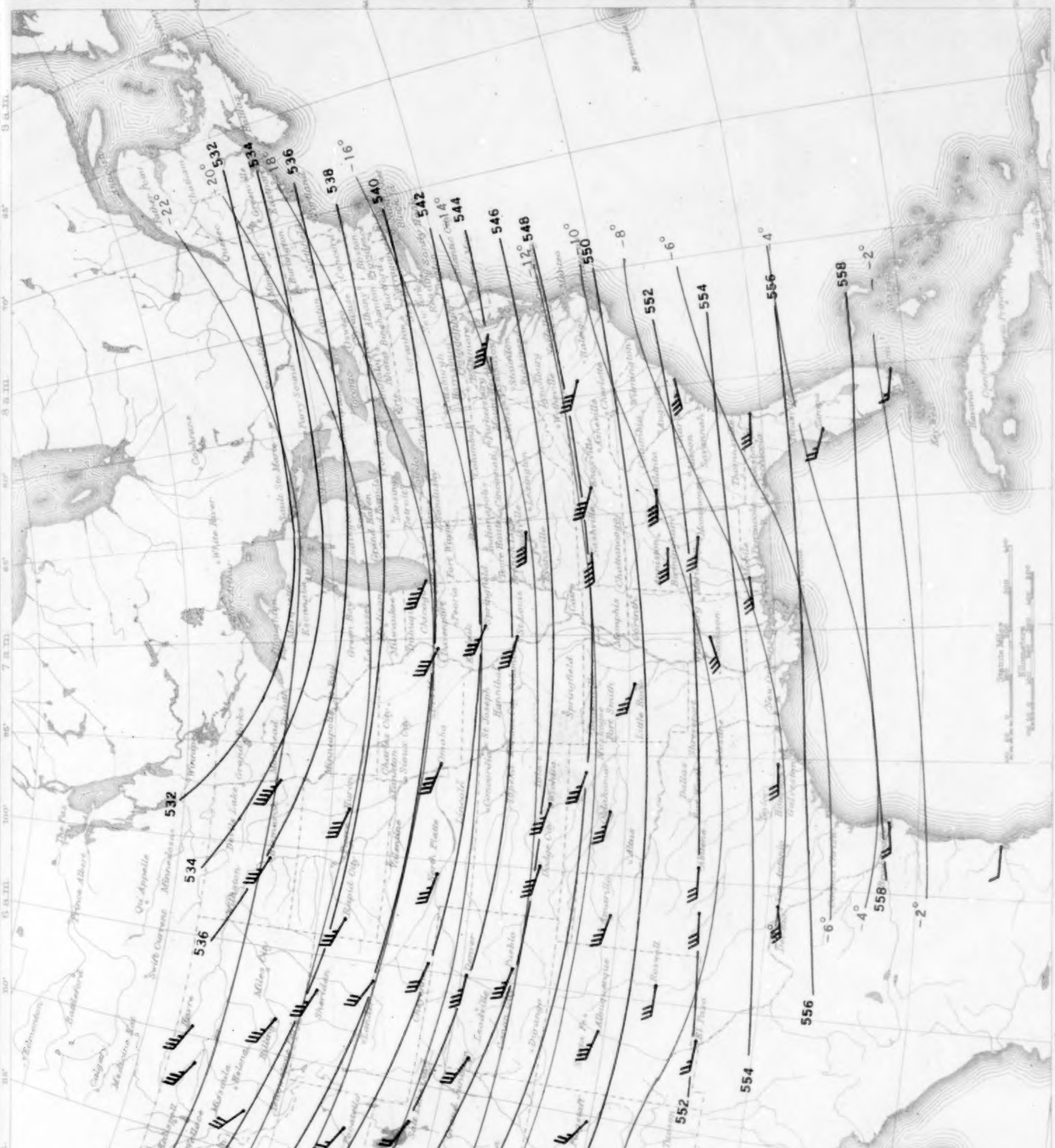


Chart X. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E. S. T.) and Resultant Winds 5:00 p.m. (E. S. T.) for 5,000 Meters (m. s. l.) November 1940

Chart XI. Isobars (mb) Isotherms (°C.) 1:00 a. m. (E. S. T.) and Resultant Winds 5:00 p. m. (E. S. T.) for 10,000 Meters (m. s. l.) November 1940

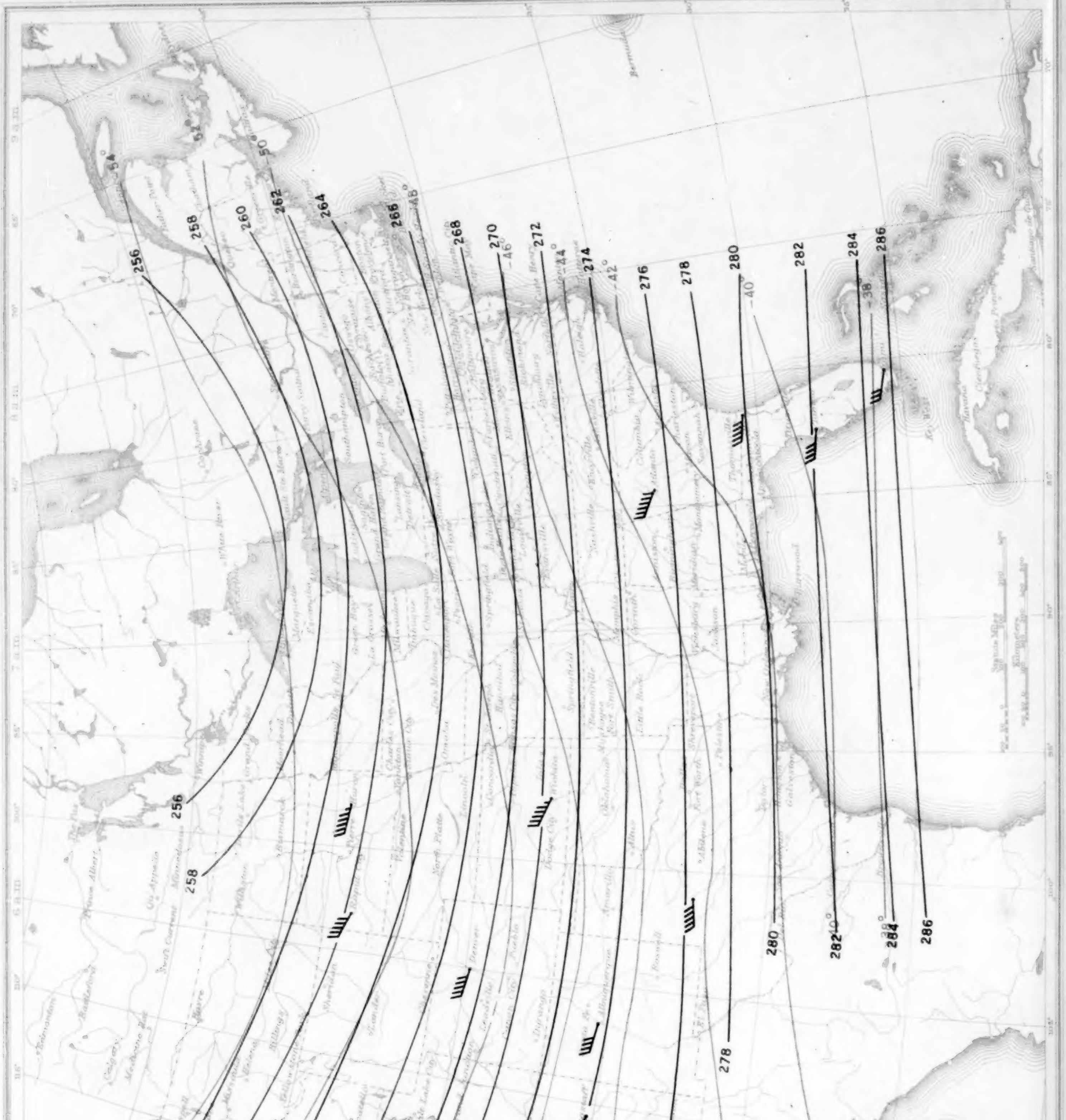


Chart XII. Mean Isentropic Chart, November 1940 (Potential Temperature 298° A.)

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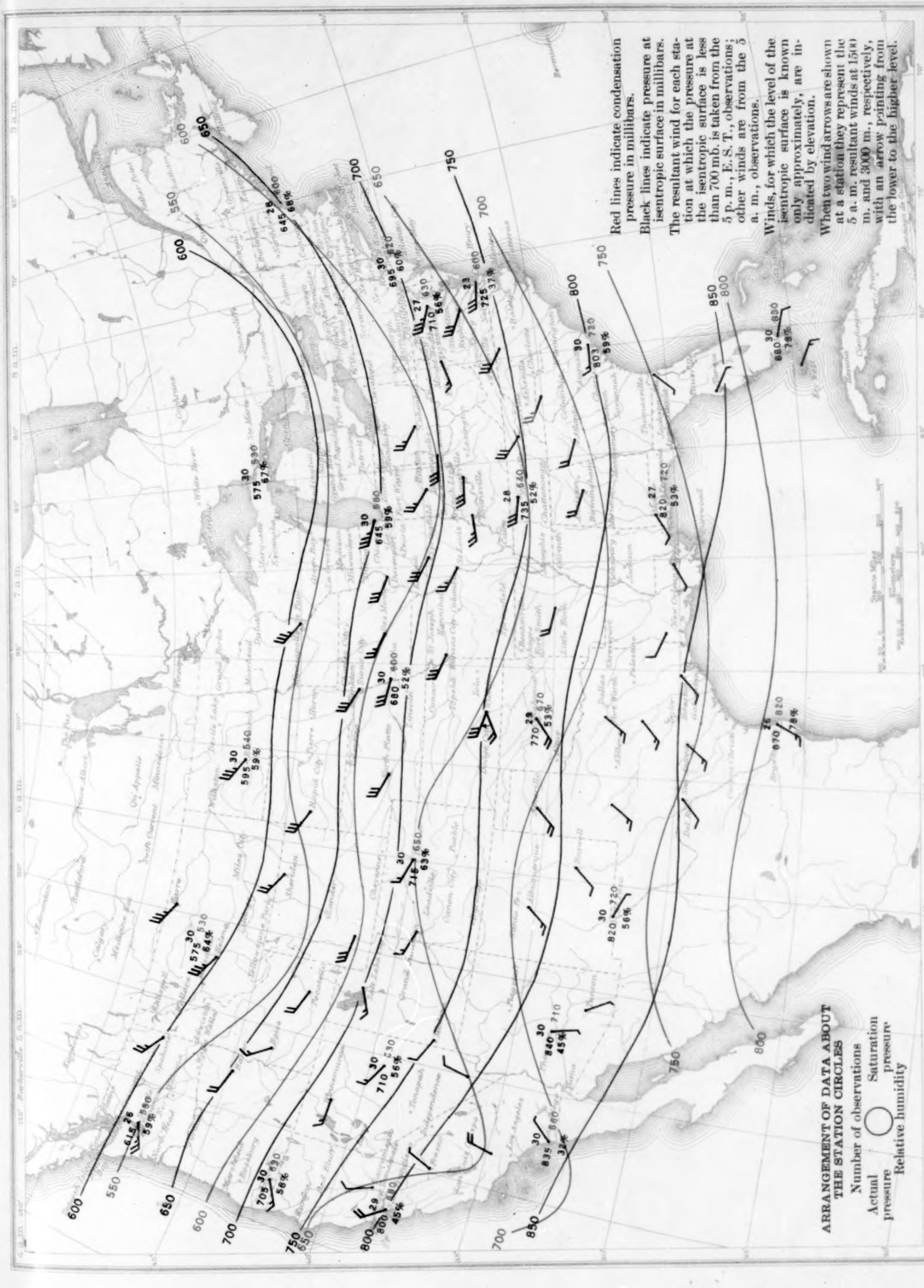

Chart XIII. Mean Tropopause Data, Altitude (km.) (m. s. l.) Temperature (°C.) November 1940
(Data from table 4)